INSTITUTE NOTES.

JUNE, 1940.

TELEGRAPHIC ADDRESS.

Telegrams and cables for the Institute should be addressed: "INSTPETECH BIRMINGHAM."

NEW FORMS OF TRANSFER.

The temporary forms of application for Transfer from one category of membership to another, which were used during 1939, are no longer accepted by the Council. The Council has approved a new Form of Application for transfer, requiring particulars of a candidate's experience and qualifications obtained subsequent to the date of election or previous transfer. This Form must carry two supporting signatures from Fellows, Members or Associate Members of the Institute.

Copies of the Transfer Form are obtainable from the Secretary.

CANDIDATES FOR ADMISSION.

The following have applied for admission to the Institute or transfer to another grade of membership, and in accordance with the By-laws the proposals will not be considered until the lapse of at least one month subsequent to the issue of this *Journal*, during which any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of any candidate.

The object of this information is to assist the Council in grading candidates according to the class of membership.

The names of the candidate's proposer and seconder are given in parentheses.

GIBBS, Eric Clarence, Engineer, 15, Worsley Road, Hampstead, London, N.W. 3. (Pilot-Officer, R.A.F.V.R.) (*C. B. Horwood.*)

HAWORTH, Alfred John, B.Sc., A.R.S.M., Geologist, c/o the Burmah Oil Co., Ltd., Chauk, Upper Burma. (*J. Coates; T. J. F. Armstrong*) (*Trans. to A.M.*)

JEFFREYS, Lynn John Lewis, Chemist, The Pharmacy, 213, Neath Road, Briton Ferry, Glam. (*W. C. Mitchell; A. E. Holley.*)

LEWIS, Robert Illtyd, B.Sc., Chemist, c/o Asiatic Petroleum Co., Ltd., St. Helens Court, Great St. Helens, London, E.C. 3. (*E. C. Williams; J. Kewley.*)

MILLS, Leonard, Chemist, 55, County Road, Ormskirk, Lancs. (*Vigzol Oil Refining Co., Ltd.*) (*P. Bilton; S. Elliman.*)

MOON, Alec, Engineer, c/o Messrs. Shell-Mex & B.P., Ltd., Shell-Mex House, London, W.C.2. (*R. G. Strickland; H. E. Priston.*)

MOORE, Lancelot Frederick, Manager, 22, Matham Road, East Moseley, Surrey. (*W. B. Dick & Co., Ltd.*) (*J. C. Jennings; A. J. Sear.*)

PINDER, John Cuthbert, A.I.C., Chemist, 63, Marshall Drive, Bramcote, Nottingham. (*British Celanese, Ltd.*) (*J. E. Haslam; H. S. Kiernan.*)

ROUGHSEDGE, Norman Donovan, Manager, "Conway" Silksworth Lane, Sunderland, Co. Durham. (*Sunderland Oil Co., Ltd.*) (*R. B. Hobson; F. J. Cox.*)

SIMPSON, Michael John, Chemist, 167, Waldegrave Road, Teddington, Middx. (*Snowdon & Sons, Ltd.*) (*W. H. Hoffert ; E. R. Redgrove.*)

SMITH, James Edward, Ph.D., Geologist, c/o U.B.O.T., Ltd., Point Fortin, Trinidad, B.W.I. (*A. G. Hutchison ; G. S. Taitt.*)

SMITH, Roland Wilfred John, M.Sc., Manager, c/o Shell Refining & Marketing Co., Shell Haven, Nr. Stanford-le-Hope, Essex. (*J. Kewley ; W. W. Goulston.*)

STOTT, Victor Howard, Director, "Westmond," Prestwich Park North, Prestwich, Manchester. (*Matthew Wells & Co., Ltd.*) (*J. E. Southcombe ; J. E. Haslam.*)

ARTHUR W. EASTLAKE,
Honorary Secretary.

BRANCH NOTES.

NORTHERN BRANCH.

The Annual General Meeting of the Northern Branch was held in Manchester on Thursday, 23rd May, 1940. After the adoption of the Annual Report and Accounts of the Branch, the meeting expressed its appreciation of the services rendered to the Branch by Mr. A. McCulloch as Chairman and Mr. J. E. Haslam as Hon. Secretary during their term of office.

The following were elected as the Northern Branch Committee for the 1940–1941 Session :

Chairman : J. CUTHILL.
Deputy Chairman : J. E. HASLAM.

Messrs. C. E. BURNETT, H. O. CLAYTON, Capt. W. T. COLLINS, Major T. G. PROVEST, V. H. STOTT, G. H. THORNLEY, E. W. UNMACK.

Hon. Secretary : E. J. DUNSTAN. *Hon. Treasurer :* G. M. DAVIES.

After the Annual General Meeting Mr. E. A. Evans (Member of Council and Chairman, Lubrication Group) gave an Address entitled "Stepping Stones to Standardisation."

TRINIDAD BRANCH.

Committee.

At the Annual General Meeting of the Trinidad Branch held on 10th January, 1940 the following Committee was elected :

Chairman : L. A. BUSHE.

Messrs. A. F. CASTLE, H. W. REID, E. C. H. THOMAS, L. K. WAITE.

Hon. Secretary : C. C. WILSON.

The Annual Report and Accounts of the Trinidad Branch are given on page 321 of the present *Journal*.

Mr. A. F. CASTLE has been acting as Honorary Secretary during the temporary absence of Mr. Wilson owing to illness.

NEW BRANCH AT STANLOW.

A new Branch of the Institute at Stanlow, Cheshire, was inaugurated on 13th March, 1940. Sectional meetings of the Northern Branch had already been held at Ellesmere Port. These had met with such success, that arrangements were made for regular meetings during the remainder of the 1940 Session.

Dr. A. E. Dunstan (Past President) addressed a well-attended meeting on Friday, 3rd May, 1940, on the subject of "Utilisation of Refinery Gases." The Chair was occupied by Mr. J. S. Parker and those present included Mr. A. McCulloch (Chairman, Northern Branch), Mr. J. A. Oriel (Member of Council), Mr. J. E. Haslam, Mr. J. C. Wood-Mallock and the Secretary of the Institute.

Following discussions with the Committees of the Northern Branch and the Stanlow Section, a request was addressed to the Council to accord the status of a Branch of the Institute to the Stanlow Section. This request was unanimously acceded to by the Council at its meeting on the 16th May.

The following members of the Institute have been elected members of the Stanlow Branch Committee:

Chairman: J. S. PARKER.

Messrs. G. DAVIDSON, G. W. DORRELL, A. EVANS, D. M. GLENDINNING, J. W. VINCENT.

Hon. Secretary and Treasurer: J. C. WOOD-MALLOCK.

The Committee has in hand an interesting programme of Papers and Lectures for the 1940–1941 Session covering different aspects of refining technology.

PETROLEUM TECHNOLOGY IN 1939.

Volume 5 of the Annual Reviews of Petroleum Technology, covering 1939, is to be published in August 1940. Copies will be available to members and annual subscribers to the *Journal* at 5s. 6d. a copy, post free ($1.35).

Orders for this publication should be sent to the Institute as soon as possible, as only a limited number of copies will be printed.

The price of non-members' copies will be 11s., post free ($2.70).

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Vol. 26. No. 200. June 1940.

THE ANALYSIS AND TESTING OF LUBRICATING GREASES.*

By M. W. Webber.

As this paper is based on work carried out in the laboratory of a works which is solely engaged in the manufacture of lubricating grease and allied products, there is no reference to service conditions. Its scope is confined solely to soap greases.

The appearance of the grease is the first item in its examination. From this it is possible to learn whether it is well made, smooth and of uniform texture, free from aggregates of soap, separated oil, whether it is made from lime or soda soap, and if of fibrous structure. The chemist has much to learn from this preliminary observation. A trained observer can tell at a glance much of what he will subsequently prove by a detailed laboratory examination. It is therefore important that the eye should be trained in observation. Then the nose should be familiarized with the odours emanating from greases. Much work can be eliminated if fats can be detected by smell. A cup-grease made from fatty acids has a different smell from one made from neutral fats, and most high-temperature soda greases possess characteristic odours.

Soap Base and Content.

At least 90 per cent. of the greases on the market contain either lime or soda soaps. As a rule, these are readily distinguished by dropping a little on to boiling water. Soda-soap greases immediately render the water milky, due to soap dissolving in the water and emulsification of oil, whereas lime-soap greases are unaffected by the water. When the two soaps are present in the same grease the test only gives indication of soda soap. Greases made from lead soaps frequently sink, due to their high specific gravity, but this depends on the percentage of lead and any aeration. Aluminium-soap greases are usually detected by their transparency and their elasticity when heated. Other soaps, such as zinc, barium, magnesium, and potassium, are encountered on rare occasions, and must be sought in the ash after incineration.

The soap content is usually determined by decomposing the grease with dilute hydrochloric acid, extracting with petroleum ether, and then titrating the washed ether solution, which contains both the fatty acids from soap and any free fatty acid originally present. After due adjustment for the latter, the soap content is calculated, using an acid value of 200. If greater accuracy is desired, the fatty acids can be separated and weighed, and the exact acid value determined.

The operations sound simple and straightforward, but difficulties in manipulation are often experienced. A simple alternative method is to extract the grease with acetone in a Soxhlet. Experience with greases of known composition has shown that an accuracy of 0·2 per cent. is readily

* Presented to a Meeting of the Lubrication Group of the Institute at The Royal Society of Arts, London, W.C. 2, on Thursday, 22nd February, 1940.

obtained. This method is particularly useful in the case of lime-soap grease made with wool-grease stearines, as the unsaponifiable portion is completely soluble in hot acetone. When using the normal method, which is described above, it is impossible to obtain sharp separations. It is preferable to dehydrate the grease by drying in an oven before extraction in the Soxhlet, and base calculations on the original weight of the grease.

About 5 grams of a lime-soap grease can be extracted satisfactorily with 60/70 mls. of acetone in 1 hour. Soda-soap greases may require extraction for at least 3–4 hours, particularly those of high soap content and pronounced fibrous structure. With this method there is a great saving of time and trouble in most cases, and it is equal in accuracy to the normal method. It may be that extraction can be speeded up by the use of a solvent of rather higher boiling point.

Should fillers be present, the contents of the thimble should be extracted again with alcohol in the case of soda-soap greases, and toluene in the case of lime-soap greases. The fillers can then be examined and weighed, and the necessary adjustment made.

The general adoption of a standard extraction method for the determination of soap content of lubricating greases would probably avoid difficulties sometimes experienced when the laboratory of the user is more accustomed to analysing quite different products.

From the user's point of view determination of the soap content is becoming less important, as is shown by the present tendency to omit strict details of the composition when formulating specifications.

Mineral Oil Content.

The mineral oil is determined by decomposing the grease with dilute hydrochloric acid and extracting with petroleum ether, separating the ether solution, saponifying the fatty acids and any fat present, and determining the unsaponifiable oil in the normal manner. The mineral oil will, of course, be contaminated with any unsaponifiable matter from the fats used in the grease, but this usually does not affect appreciably the examination of the mineral oil for colour, viscosity, gravity, flash point, and pour point.

Naturally, only a small quantity of oil can conveniently be extracted. Viscosity at 140° F. is usually determined in a small U-tube viscometer. The specific gravity is found by adjusting a mixture of alcohol and water so that a drop of the oil just remains in suspension, and then taking the gravity of the mixture. An approximate estimation of the open flash point can be made by carefully heating a little of the oil in a crucible on a sand-bath. The pour point can be determined by cooling the oil in a test-tube, but the Air Ministry apparatus can be used if sufficient oil is available.

An alternative method for the determination of the mineral oil content is by evaporation of the acetone extract resulting from decomposition of the grease with acetone in a Soxhlet. The residue is weighed and reported as mineral oil. The oil is contaminated with free fatty acid, neutral fat, and unsaponifiables, but the total of these is usually less than 1 per cent. If an accurate analysis is needed, separate determinations will be made of the free acid and free fat, and due allowance made. A separate estimation

of the unsaponifiables from the fats is extremely difficult, and no method is suggested. The contaminated mineral oil can be used for the physical tests, as the contamination will not cause errors any greater than those due to the method of test of small quantities of oil.

Free Acid and Alkali.

The methods described in I.P.T. Serial Designation L.G.5 are reliable and satisfactory for routine estimation of free acid or alkali. However, in the case of soda-soap greases, containing appreciable amounts of free fat as well as free alkali, it is preferable not to boil the solution, as any error due to the presence of carbon dioxide will always be less than that caused by saponification of neutral fat on boiling. The determination of free acid in aluminium-soap greases can be effected by extraction with cold neutral alcohol and then titrating. A suitable procedure is to weigh 10–15 grams into a conical flask, shake thoroughly for 5 minutes with 50 mls. alcohol, allow to settle, and decant the alcoholic extract. This should be repeated, the extracts united and titrated in the normal manner.

While free alkali in soda- or lime-base greases may have little effect on bearing metals, the presence of a large proportion is definitely undesirable, as it affects adversely stability at elevated working temperatures. If the grease is to be used with alloys containing aluminium or magnesium, no free alkali should be allowed.

The determination of free fatty acid (mineral acid is, of course, never to be found in a compound lubricating grease) is most necessary, as the presence of any considerable amount is the principal cause of corrosion of bearing metals. A reasonable limit is an acid value of 0·2 mg. KOH per 1 gram of grease—*i.e.*, approximately 1 per cent. f.f.a. as oleic acid. A grease complying with this will normally be satisfactory from the point of view of corrosion, whilst the free fatty acid can be sufficient to ensure stability when heated.

Specifications have been issued which specify the *p*H value for the determination of freedom from acidity or alkalinity, but this would appear to be of limited value with lubricating greases, as appreciable quantities of free fatty acid make little or no difference to the apparent *p*H value.

Water Content.

The water content is most accurately determined by distillation using the Dean and Stark method as described in I.P.T. Serial Designation F.O. 14. It is not satisfactory to determine the water by heating in an oven, as this does not ensure the removal of all water from the grease. In addition, there may be some loss of volatile constituents of the mineral oil. These two errors seldom exactly counterbalance one another. The total loss of volatile matter may in some cases be considered to be of importance to detect the use of inferior oils.

In lime-soap greases the presence of a certain amount of water is essential for their stability, but an excess is to be avoided. Some specifications call for a limit of 1 per cent. for water without due concern about the soap content. In general the optimum proportion of water is 6 per cent. of the soap content. Such a limit would allow the presence of sufficient water for

the manufacture of a stable grease, whilst there would not be an excess to cause corrosion.

In the case of sodium or aluminium base greases the water content may be reduced to negligible proportions, although in the case of greases containing large amounts of soda soap a quantity up to 0·5 per cent. of water may be retained, and this will persist however high the temperature of dehydration during manufacture.

Unsaponified Fat.

The content of unsaponified fat can be determined either from the petroleum ether extract after decomposition with hydrochloric acid and extracting with ether, or from the acetone extract resulting from the soap determination using the Soxhlet apparatus as described earlier in the paper. In both cases the free fatty acids in the solution are neutralized, followed by an estimation of the saponification value. The percentage of neutral fat can then be calculated with sufficient accuracy if the saponification value of the fat is taken as 195.

Until recently it was thought that the deliberate inclusion of unsaponified fat in a grease improved both stability and lubricating efficiency. It is now generally agreed that the presence of free fat is to be avoided. Its decomposition leads to the formation of undesirable products. Greases stable to heat can be made without excess neutral fat. Tests on the Timken machine have shown that the presence of free fat does not appreciably reduce friction or increase load capacity.

Ash Content.

The importance of the determination of ash left on ignition by a lubricating grease is often denied. It does, however, serve useful purposes. Glazed porcelain crucibles are quite satisfactory for the ignition. The grease should be slowly and steadily burnt off at as low a temperature as possible. The crucible is then heated to redness until all carbonaceous matter has disappeared and ignited to constant weight.

The ash can then be examined qualitatively or quantitatively by the usual methods for the determination of base and mineral fillers. In the case of pure greases the determination of ash will give a very good idea of the amount of soap present. The ash content can be used as a rapid routine check on successive deliveries of the same grade of grease.

Where mixed-base greases are under examination, analysis of the ash is a matter of importance, as it is often the only practicable means of determining the types and proportions of soaps present.

Impurities.

By impurities, as distinct from fillers, are meant such foreign matters as grit, dirt, particles of wood or metal from containers and plant. The presence of impurities is usually due to careless handling during packing, as most greases are carefully filtered during manufacture. Such adventitious matter can be determined visually by examination of the grease in a thin film on a sheet of glass, or on an opaque white surface. Soft lime-soap

greases can also be examined by passing them through a piece of fine muslin, and stiffer greases by forcing through finely woven wire cloth. Alternatively, the grease can be dissolved in toluene, and passed through a filter-paper, or this can be done more rapidly by extraction in a Soxhlet.

Fillers.

The expression "fillers" is usually reserved for "loading" material, such as gypsum or barytes, but the term is often taken to include such ingredients as graphite, mica, asbestos fibre, wool yarn, granulated cork, all of which are deliberately incorporated to increase the efficiency of the grease for particular applications. Mineral fillers can easily be determined from the ash, whilst combustible fillers can be separated by filtration after decomposition of the grease with hydrochloric acid and petroleum ether.

If extraction in a Soxhlet with acetone has been employed for the estimation of soap, the fillers can be examined and weighed after elimination of the soap by further extraction of the residue in the thimble with toluene. If a separate determination of soap is not made, the original grease is extracted with toluene.

Addition Agents.

As in the case of lubricating oils to-day, a number of materials are being added in small or large proportions to lubricating greases to improve their efficiency for various purposes.

Chlorinated waxes and sulphurized oils (with or without the presence of lead soap) are added to increase the load capacity of greases destined for rolling-mills, and stamping and drawing operations. The proportion of sulphur or chlorine can be determined by fusing the dehydrated grease with a mixture of sodium carbonate and potassium nitrate or sodium peroxide. The resultant mass is dissolved in water and the sulphates or chlorides are estimated.

In order to increase the adhesiveness or stringiness of greases, such materials as rubber latex and highly polymerized products are incorporated in the grease. The proportion is usually less than 0·25 per cent., and as determination by analysis is extremely difficult, no method is suggested.

Solid addition agents, such as graphite, mica, asbestos fibre, and wool yarn, are determined as fillers using the methods described earlier in the paper.

In the case of colloidal graphite the proportion present is usually from 0·05 to 0·2 per cent. and determination by quantitative methods is beset with difficulties. I have found that the best method is to dissolve the grease in toluene and to compare dilute solutions with known standards.

Corrosion.

Any corrosion caused by a grease is usually due to excessive contents of free fatty acid and/or water, and in some cases to the presence of chlorides or sulphates. A suitable method of test is to take pieces of polished copper and steel, about 1 inch square, cover them partly with the grease, and allow to stand under inverted watch-glasses for a period of at least 24 hours. After cleaning, the test-pieces should show no discoloration or pitting.

The test can be carried out at room temperature, or higher if considered advisable.

Melting Point.

Many simple methods have been suggested for the estimation of the melting point, but it is obviously desirable to have a standard method. The Ubbelohde apparatus was originally designed for the melting point of petrolatums, but during recent years it has been applied to greases in general. To obtain consistent results with soap-greases it is essential that air bubbles should not be included with the grease when filling the cup. Apertures in the metal holder must be kept clear, and the rate of heating accurately controlled. Discrepancies in the results obtained with the Ubbelohde apparatus in different laboratories are principally due to lack of standardization of the cups, especially as regards the orifice. Standardization of the method has recently been undertaken by the British Standards Institution, and no doubt it is a subject which will be considered further by the Institute of Petroleum at an early date.

The obtaining of consistent results with high-melting-point soda-greases of fibrous and block types is difficult with the Ubbelohde apparatus. A suitable method of test for such greases, which will give consistent results, is to take a piece of wire about 3 inches long, make a small loop at one end, and then coil the wire round the thermometer stem and adjust so that the loop is level with the tip of the bulb. A small portion of the grease, sufficient to yield three or four drops, is then fixed in the loop so that it is in contact with the thermometer bulb. The thermometer is then placed in a test-tube, which is heated in the usual way in a bath of oil or glycerol.

The determination of the melting point of a grease is of great importance, but the conventional methods do not always give complete information of the results to be expected in service. A useful test to employ in this connection is to make 15 grams of the grease into a cone in a flat metal dish—the lid of a tin will serve quite well—and then to place this in an oven maintained at a temperature 30–40° F. below the apparent melting point of the grease. It will often be found that, of two greases having similar melting points, one will maintain its structure unchanged, whilst the other will break down and flow out to a common level.

Consistency.

The only method for the determination of the consistency of a lubricating grease that has received official recognition is that employing the penetrometer and procedure described under I.P.T. Serial Designation L.G.18 and A.S.T.M. D.217–33.T. The use of this apparatus does give reproducible results, and it is exceedingly useful for the control of works batches and for specification purposes. Alternative methods in regular use, such as the Karns–Maag, the method described in Air Ministry specification D.T.D. 143. B, and sundry others employed in various works laboratories, have in common the allowing of a solid plunger to penetrate the grease when dropped from a known height—the consistency being taken as a reciprocal factor of the distance to which the plunger sinks below the surface of the grease.

All these methods give results which are not compatible with those obtained with the I.P.T. apparatus. Investigation has shown that the difficulty is principally due to the fact that the cone penetrometer does not respond sufficiently to changes in the viscosity of the mineral oil content of the grease. For example, particulars are given of the comparative penetration figures obtained with the I.P.T. and the D.T.D. 143. B apparatus when testing two greases, of which "A" is based on 100 Pale Oil, and "B" on 500 Red Oil. Both greases were made by the same method and with the same fats, and have identical lime-soap contents—namely 12½ per cent. All tests were made on the worked greases.

	I.P.T. Method		D.T.D. 143. B Method	
	"A"	"B"	"A"	"B"
0° C. (32° F.) . . .	26·0 mm.	20·5 mm.	0·6 in.	0·25 in.
25° C. (77° F.) . . .	30·0 mm.	26·5 mm.	1·0 in.	0·55 in.
60° C. (140° F.) . .	34·2 mm.	31·5 mm.	1·45 in.	1·15 in.

In view of the almost universal use made of the I.P.T. apparatus, these results were checked by ascertaining the rates of feed of both greases at the three temperatures from a constant-pressure-spring grease cup. While the exact figures obtained varied with different cups, it was obvious that the plunger or D.T.D. 143. B method gave results which were the more truly indicative of the rate of feed. Further, as the outlet of the cup was a tube measuring 1 inch in length by ⅛ inch in diameter, it could be considered as a crude form of constant-pressure grease viscometer. Accordingly, it would appear that the plunger method gives results of more practical value than the cone penetrometer, although the latter is, as stated, very useful for checking works batches of greases made from the same oil, and at the same temperature.

The D.T.D. 143. B plunger method is the more readily adaptable, owing to its compactness, for use at widely varying temperatures, and it is, indeed, already in use for the testing of greases at temperatures ranging from as low as − 50° C. to as high as 100° C. Discrepancies between the Air Ministry and other similar methods arise from the fact that in the former the tube of grease under test is contained within another tube and the displaced grease rises round the plunger, whilst in the other methods the grease is in an open container giving a comparatively large free surface. In the Karns–Maag apparatus the plunger is spherical instead of cylindrical, and little heed is taken of the extent of the working to which the grease has been submitted.

Whatever the method of determination employed, it is essential that the grease should be tested in the "worked" condition. The I.P.T. worker is perfectly satisfactory. The determination of the unworked consistency is of little practical value, and in any case it is difficult to obtain consistent figures even when using original containers. However, the determination of the ratio between the unworked and worked penetrations does keep a check on manufacturers who draw their greases at rather high temperatures and send them out with false apparent consistencies. Modern mechanical greasing devices do thoroughly work the lubricant before delivery to the

bearing, and it is the consistency at the delivery point that matters. In any case, greases should be preworked as far as possible during manufacture for such methods of application, in order to ensure that as consistent a grease as possible is supplied through the lubricator.

Stability at High Temperatures.

During recent years increasing interest has been taken in the behaviour of lubricating greases at high working temperatures, more particularly in the case of lime-soap ball and roller-bearing greases at temperatures above their melting point which would also cause more or less complete dehydration. This interest is justified, but the value of such a test is not so great as it would appear to be from the amount of discussion which it has caused. It must be remembered that a grease is only used for the lubrication of such bearings where retention and protection are of primary importance, and no grease is deliberately chosen for use at temperatures above its melting point. Accordingly, it would appear that a more prolonged stability test at, say, 65–70° C. has more practical value, and this also applies to greases intended for general machinery lubrication.

The result of the more stringent test of subjecting the grease to a temperature of 120° C. or over is not always correlated to the stability of the grease at more normal working temperatures. Such a test has, however, its value, in that it does ensure that separation will not take place if the grease is overheated for a short time. For example, this could occur in the event of particularly severe overloading, or if the grease should channel, in which case the lubricant would not be drawn into the ball grooves until sufficient heat had been generated to make the grease at least semi-fluid.

As regards the method of conducting such heat tests, that specified by Messrs. British Timken, Ltd., is the one in most common use in this country. While this test does give useful information, it is somewhat arbitrary, and the method specified by the War Department Chemist, the Air Ministry, and the London Passenger Transport Board is preferable. In both methods the temperature is practically the same—namely, 250° F. or 120° C.—and while the specified stirring of the grease in the Timken test does ensure more complete dehydration, this is balanced by the fact that the alternative method specifies heating at 1 hour instead of the Timken half-hour.

In the case of the Timken test the grease must re-set hard enough to allow of its retention in the silica tube by the cross wires, and a dehydrated grease which sets to a hard gel will usually break down rapidly when subjected to agitation. On the other hand, many greases when subjected to this heat test will return to a softer and more greasy gel which is more stable on agitation, and these pass in a more satisfactory manner the alternative test. From the point of view of the works chemist, the Timken test requires more time and manipulation than does the test used by the Government Departments, without giving any more useful information, and this is of some importance where a number of batches have to be tested each day.

Stability at Normal Working Temperatures.

As regards stability tests at more normal working temperatures, the original practice was to heat 20 grams of the grease in a porcelain dish in an

oven for 24 hours at 70° C. Recently this test has been extended to periods of over a week, and useful information has been gained.

Apart from lime-soap greases, heat tests of high-melting-point soda-soap greases at temperatures below their melting points are definitely equally as important. These are normally carried out for periods of up to 24 hours' heating at temperatures of 100° C. or 150° C., according to the melting point of the grease and its intended application. It is essential that the grease should not harden excessively or separate oil, and much useful information can be gained by observation of the consistency and structure of the grease after heating at these temperatures.

In the case of high-melting-point block-greases, explanation of surprising differences in consumption can be found by placing cubes of the grease on, say, 10-mesh wire gauze and heating at 300° F. in an electric oven. It will sometimes be found that a block-grease will break down and percolate through the gauze at lower temperatures than another block-grease of nominally lower melting point.

Stability at High Pressures.

All compound lubricating greases tend to separate oil if exposed to high pressures for lengthy periods, and it has been necessary to develop methods of test in order to effect the necessary improvement in greases for use in spring pressure cups and modern high-pressure greasing equipment.

My own practice is to make use of two devices, the first being an ordinary spring pressure cup with a cap over the orifice, so that pressure can be maintained for any desired period, and this has the advantage of reproducing the exact conditions of use. The other device is a steel tube $\frac{3}{4}$ inch diameter and 4 inches long, with a screw cap at each end to facilitate filling and emptying; one cap is fitted with an ordinary nipple for a hand-grease gun. The tube is filled with the grease, the caps securely tightened, and pressure is then exerted by applying the hand-gun to the nipple. The tube can either be filled to capacity or air space allowed so that the effect of maintaining the grease in contact with air under pressure can also be observed. For high-temperature work the cap or tube can be placed in an electric oven.

It has been found possible to reduce separation of oil to negligible proportions in the case of lime-soap greases and stiff dehydrated soda-base greases, but soft fibrous lubricants will almost always show appreciable separation.

Stability on Storage.

It is essential that a lubricating grease should be capable of being stored either in a trade container or in a bearing for periods of at least six months, without deterioration, which may be due to any or all of three factors—oxidation, development of acidity, or separation of the mineral oil component. Of the three the latter is usually the most troublesome.

In general, it has been found that stability during storage is closely allied to stability of the grease when subjected to high pressure in contact with air, and the pressure tube previously described has been used in the development of stable greases. Also, a prolonged heat test—say, seven days at 70° C.—gives useful information. One can safely say that a grease which

shows no appreciable separation of oil, oxidation, or increase in acidity when submitted for one week to the pressure and heat tests, will retain its characteristics without deterioration for at least twelve months in storage, and probably considerably longer.

Other tests consist of centrifuging the grease, or of observing the amount of oil extracted by capillarity when the grease is placed in contact with filter-paper. The first of these is of no great value, as the separation of oil during storage is not due to the force of gravity, and the second does not give reproducible results. Neither test gives any evidence of resistance to oxidation or acid formation.

Naturally, samples of grease should be kept in storage both in the usual containers and in bearings, and be examined at regular intervals for any evidence of deterioration in order to confirm the results of accelerated laboratory tests.

Load-Carrying Capacity.

The most convenient apparatus for the determination of the load-carrying capacity of a lubricating grease is the Timken Lubricant Testing Machine. Except in the case of greases having definite E.P. properties, it is best to run the machine at 400 r.p.m.—*i.e.*, 200 feet per minute rubbing speed—instead of the more usual 800 r.p.m., and it is then possible to obtain reproducible results of great value for comparative purposes.

In the case of lime-soap cup-greases it is found that load capacity increases with increasing soap content, especially in the case of those made with wool stearine, doubtless due to the presence of wool wax. In all cases the efficiency of the grease is much greater than that of the basic oil. In the case of soda-soap greases there is less variation with soap content, although the load capacity is still much greater than that of the mineral oil content. Some typical results are given below.

Approximate Composition.		Timken O.K. Value.
Oil Content. Per cent.	Soap Content. Per cent.	Lever Load. lb.
100 Pale.	Lime Soap.	
100	—	17
87	12	33
81	18	37
75	24	40
500 Red.	Lime Soap.	
100	—	21
89	10	36
84	15	41
100 Pale.	Soda Soap.	
80	20	31
70	30	33
500 Red.	Soda Soap.	
80	20	35
Bright Stock.	Soda Soap.	
85	15	38

The Cornell (Faville-Levally) Machine is of no use for testing greases, but these results with the Timken Machine may be compared with tests on the Almen Machine made by Evans (I.Mech.E. "Discussion on Lubricants"

1937). It is worthy of note that in the case of the Timken Machine the test-pieces are subject to a copious flow of oil, but with greases only a small supply is fed from the screw-down lubricator, and temperatures of the test-pieces are correspondingly high. The figures quoted also agree with the statement made by Garlick (*J. Instn Petrol. Tech.*, 1934) to the effect that ordinary cup-greases made with light spindle oils will give acceptable results under service conditions in which the lubricating oil alone would prove unsatisfactory.

Satisfactory extreme pressure greases for anti-friction bearings in rolling-mills are made by incorporating sulphurized fatty oil in a lead-soap-base grease, and lever-load capacities up to 70 lb. at 800 r.p.m. on the Timken Machine can be obtained. Lime- and soda-soap greases can also be treated with sulphur and chlorine compounds to give equal load capacities with, in some cases, greater stability than the lead-soap products. The difference between the two lies principally in the fact that the lead soap-sulphur greases more readily resist shock-loading without scoring, and when running tests at near the breakdown points this is of importance, as weights of 60–70 lb. can be easily applied a little too roughly.

Wear tests can also be carried out using the Timken Machine—the wear being measured both by the width of the scar on the block and the loss in weight of block and cup.

Low Temperature Efficiency.

Requests are sometimes made for information concerning the " cold test " of a grease, and it can be said that it is roughly equivalent to the pour-point of the mineral oil for soap contents up to approximately 12½ per cent. For higher concentration of soap there is a definite increase, which varies with the oil, soap stock, water content, etc.

Penetration tests at low temperatures can be readily carried out using the plunger-type apparatus described in Air Ministry Specification D.T.D. 143. B. In most cases there is a steady decrease of penetration with fall in temperature until it becomes negligible. Further information of the resistance due to stiffening of the grease at low temperatures can be obtained by making use of the apparatus described in Air Ministry Specification D.T.D. 201, which consists essentially of a steel ball rotated in a brass socket by means of weights and pulleys. Here the temperature at which there is a marked increase in the time taken for rotation of the ball is usually quite definite, and the cold test can be reported to within 5° C.

However, except for exceptional conditions of service, it is usually sufficient that the grease shall be easily workable after exposure to 0° C. for, say, 2 hours, and this stipulation is embodied in a number of specifications.

It is regretted that lack of time prevents giving more precise details of the various tests and their formation into a complete progressive scheme of grease analysis. Also, it has not been possible to include details of specific tests made with greases destined for specialized applications—for example, water-pump greases, wheel-bearing greases, steering-gear greases, universal joint greases, etc.

The author's thanks are due to Mr. L. A. Phillips, who has carried out most of the tests to which reference is made.

THE INSTITUTE OF PETROLEUM

A MEETING of the Institute of Petroleum was held at the House of the Royal Society of Arts, John Adam Street, London, W.C. 2, on Thursday, 22nd February, 1940, at 5.30 p.m. Mr. E. A. Evans, F.Inst.Pet., M.I.A.E., occupied the Chair.

The Chairman, in introducing Mr. M. W. Webber, said that the paper which was being read that evening was invited before the war commenced. The invitation was made with the express intention of producing a discussion upon the possibilities of standardizing tests for grease. The Institute had standardized tests for petroleum products, and had included a few tests for grease. The Council was of the opinion that greases should now receive further consideration.

Mr. Webber's paper would serve as a foundation stone upon which the standardization of grease testing could be erected. Mr. Webber was known to many as a specialist on grease, and a member of the Grease Panel of the Institute.

The following paper was then read :—

" The Analysis and Testing of Lubricating Greases " by Mr. M. W. Webber. (See pages 273–83.)

DISCUSSION.

THE CHAIRMAN said that members would appreciate the reasons for the limited supply of pre-prints. He knew that it was difficult to marshall all the facts as the paper was being read.

Mr. Webber had suggested the estimation of unsaponifiables by extraction with acetone. The method was simple, and accurate to 1 per cent.

He also suggested toluene extraction, subsequent to acetone extraction, for the estimation of soaps. The residue, after the extractions, was fillers, mica, graphite, and other solid additives.

No doubt members would express their opinions on these methods. If such methods were satisfactory, they would be very attractive.

Mr. Webber stated that in soda-soap greases both free fat and free alkali might be present. Therefore in the estimation of the free alkali the alcoholic solution should not be boiled. Members would probably remember that in " Standard Tests " a similar warning was given.

The dimensions of the Ubbelohde apparatus, which are given in " Standard Tests," were the result of careful consideration by the Institute. For the purposes of the British Pharmacopœia, it was felt that the actual thickness of material in the cup should be specified. At first it appeared to the British Standards Institution that to standardize the internal dimensions of the cup as well as the external might lead to manufacturing difficulties. Any serious modification of the present apparatus might easily lead to difficulties in the petroleum world. Happily, agreement was reached on behalf of the Institute of Petroleum and the British Pharmacopœia. It was believed that the B.S. apparatus would be satisfactory to members of the Institute. It might be prudent to remind members that the British Pharmacopœia contained legal standards.

Mr. Webber stated that worked samples were infinitely more important than unworked. If that was the case, were they not wasting their time testing unworked samples ? A definite lead was required on that point.

The Institute definitely wanted a lead from the members on the question of standardization of grease tests. It was therefore important that members should give their views freely.

DR. E. R. REDGROVE said the meeting was a very important one, because it was the first which the Institute had held since the war broke out. The large attendance was a clear indication, he thought, that the meetings of the Institute should continue to be held in spite of the war.

The members were much indebted to Mr. Webber for his paper. Although it had been contemplated last August, he did not suppose that it had been written before the war broke out, and many members knew how busy Mr. Webber must have been since that day. It took a great deal of time to write any paper, and Mr. Webber must have devoted a great deal of time and thought to bring out what seemed to him some very important points, which he hoped would be fully discussed later on.

He did not propose to make any comments on anything which Mr. Webber had said specifically, but he wished to refer to the necessity of standardizing tests. It was the function of the Institute, he thought, to take charge of the matter, and not to allow a state of chaos to come into being in which different interests each had their own pet ideas on testing to which they expected manufacturers to adhere. If any body was to investigate any question connected with the testing of petroleum products in the broadest sense, he thought that that body should be the Institute of Petroleum.

The Institute had its Standardization Committee, and he was confident that the discussion to follow would give to that Committee a good indication of where revision or restandardization of grease tests was called for.

In conclusion, he wished to thank Mr. Webber for his very valuable and interesting paper.

DR. E. R. STYLES said there was one point that he thought might be made regarding the consistency. He felt that the I.P.T. method would cover a wider range of greases more satisfactorily than the D.T.D. 143 method. It had been found that with very soft greases the I.P.T. method could still be applied, whereas with the Air Ministry method the plunger would penetrate right to the bottom of the container. In the paper, attention had been directed to the relatively small difference in the numerical value of the comparative tests with the two greases " A " and " B " in the case of the I.P.T. method, and the relatively large difference between the same two greases when tested by the Air Ministry method. He thought that, if it was remembered that in one case a conical penetrator was used and in the other a cylinder of small cross-sectional area, the reason for that unfavourable comparison would be better appreciated.

With regard to Mr. Webber's comments in relation to the working of greases during manufacture, the meeting might like to hear of an experience which he had some years ago, when engaged in the actual manufacture of greases. He had occasion to notice very big discrepancies in the apparent consistency of samples submitted to him by the works from what were alleged to be barrels of grease taken from the same batch. When the matter was investigated, it was found that the rate of cooling of the grease influenced the penetration obtained, even though that test was made after working by the I.P.T. method. Thus it was found that a sample drawn from the outside of a barrel gave a very stiff grease as the result of the rapid cooling, whereas one drawn from the centre subject to very slow cooling was much softer. The point regarding pre-working during manufacture to ensure uniformity appealed to him very strongly, because there was a great deal of difficulty in convincing customers that they had a satisfactory grease when they found that from one package they could get different test results according to the point from which the sample was taken.

THE CHAIRMAN asked whether Dr. Styles could make any suggestion with regard to the matter from the inspection point of view.

DR. STYLES said that of course the grease had been drawn off into the containers at a relatively high temperature. He thought the more modern method was to allow the grease to reach something approaching atmospheric temperature in shallow trays, and then to shovel it out into the final package. In the case that he had quoted the material was poured into the container and then allowed to cool—a very slow process when wooden barrels were used, leading to a big difference in rate of cooling between the centre and outer part of the barrel. He was going back some years, but, if his memory served him aright, the figures were of the order of 200 on the outer material and 300 on the inner material by the A.S.T.M. method; that was on a medium cup grease. The samples were worked when they reached the laboratory.

THE CHAIRMAN: And they still varied?

DR. STYLES: Yes.

MR. F. J. S. HALL said he welcomed the paper because it seemed to him that hitherto no serious interest had been taken in lubricating greases by the higher technical minds engaged in the petroleum industry. He thought that was a pity, because the subject was a very important one, and he hoped that Mr. Webber's paper would be given as much prominence as possible. Hitherto he believed the ball-bearing manufacturers had to be thanked for enforcing greater attention to the academic side of grease-making. The Chairman had referred to the question of acetone extraction for the oil and free fat. Personally he thought that was an extremely good method and was one that he had often used himself. It was probably better carried out in a Stevens extraction apparatus than in a Soxhlet, and the grease mixed with previously extracted sawdust or similar material before being placed in the thimble. The only point in the paper which he wished to criticize was the question of acidity in the grease. He could not agree with Mr. Webber's suggestion of 1 per cent. being a desirable figure; he thought that desideratum should be nearer 0·1 per cent.

MR. H. W. CHETWIN said he wished to thank Mr. Webber for the very lucid, concise, and interesting paper that had been presented that evening. He did not think the Chairman had been quite fair to Mr. Webber in suggesting that all the tests described in the paper were extremely simple; Mr. Webber could probably agree that that was not really the case. They became simpler, of course, with constant use, but they necessarily required experience and care.

The paper covered the ground so thoroughly, in his opinion, that there was very little room for criticism. It was interesting to consider that the tests had been built up, or perhaps it would be better to say standardized, over a comparatively short period—*i.e.*, within the last twenty-five years—which was not a very long time to look back upon, though it seemed a good while in the future. Twenty-five years ago very little attention was paid to tests of lubricating grease. In fact, the average consumer had only two which he applied, and those two tests Mr. Webber had not thought it desirable to mention in his paper. The first was the colour test, which was quite easily made. The prospective buyer looked at the grease, and if it was of a colour that suited his æsthetic feelings, the grease was satisfactory; otherwise it was not. The other test might be briefly described as the thumb-and-finger test, which perhaps did not need any further explanation.

Since that time the requirements of engineers and of modern plant had necessitated a much greater knowledge on the part of the consumer, and the grease-makers had had to apply themselves to the manufacture of products which would give results never anticipated in the early days, and grease had, indeed, come into its own once more.

The specifications that were now drawn up were frequently not prepared by chemists who were acquainted with the principles of the manufacture of grease, with the result that specifications often included items which were entirely incompatible—a definite proportion of soap and a certain amount of ash which was much too low for that proportion, and requests for melting points of lime-soap greases which were far beyond the highest expectations of the salesman. There was also, he found, a tendency amongst those who were responsible for the specifications to try to do a little better every time. There were one or two well-known consumers who were constantly tightening up their specifications, with a view to seeing how much better, in their view, the grease could be—sometimes with somewhat unfortunate results.

He wished to take up the Chairman's challenge with regard to the Ubbelohde apparatus, which he considered a most unsatisfactory apparatus to use for taking a melting point. The results varied very much in the hands of different operators, due, as Mr. Webber had pointed out, to the difficulty of getting the cup standardized. Also, there was the very great difficulty of ensuring that there was no air occluded in the grease. A practice which he had found satisfactory in that connection was to press the grease through a very fine mesh before it was put into the cup, but even when that was done it was found that a number of results varied very considerably, and it seemed that certain operators invariably obtained a different result—that was to say, either a consistently higher or a consistently lower result than the results obtained by other operators.

MR. A. T. WILFORD, referring to Mr. Chetwin's remarks, said that he himself had re-drafted and revised many specifications, and had never consciously done so with a view to asking for something that could not be supplied. What he had generally done was to select the best supply obtained from a number of sources and to try to bring all the manufacturers up to that level, and that should give no cause of complaint to anybody.

With regard to tests of grease, one that he had found very useful was the penetration test, and in connection with that test there was one difficulty that he encountered as a user—namely, that it was often desired to examine the properties of a used grease, but there was not enough material to carry out the test. If there was standardization and a possibility of dealing with smaller quantities of material, it would be very useful. He had used the Ubbelohde melting-point method for some years, and it had at least kept him out of trouble.

With regard to stability, he thought the test laid down in the London Transport specification was certainly of some value and he applied it regularly. Whether it corresponded with actual service conditions he was not sure, one grease of which he had used very large quantities had consistently failed to meet the specification, but it was many years before it was discovered that there was anything wrong with the service behaviour of that grease, and then it was not very serious. The stability test did perhaps have some relation to the performance of a grease in wheel bearings and it was in this application that the particular grease to which he had just referred had eventually given trouble, thus confirming the results of the laboratory test, which indicated that the grease did not meet the specification.

THE CHAIRMAN asked Mr. Wilford whether he thought it was not necessary to standardize anything on stability.

MR. WILFORD said he did not think so. He rather liked the test to which he had referred, but, as he had pointed out, he had not any certain proof that it correlated very well with all service conditions. If heat and pressure could be combined in one test it would be a great advantage.

MR. HALL said he had been interested and surprised to hear that Mr. Webber found the acetone extraction method always satisfactory. Some years ago he had had to test universal joint greases, which generally had a soda base, though a certain number had a lime base, and he had not found the acetone extraction method at all satisfactory. He had been particularly interested in the properties of the oils separated from the grease, but it had proved absolutely impossible, at any rate within his own experience, to get the oil free from ash or sodium or calcium, as the case might be. He had tried centrifuging and the use of acid material, but the same trouble had been experienced, and in the end he had found the A.S.T.M. method, modified for large-scale work, was much the best.

Another point he wished to mention was in relation to the dark-coloured greases which were usually handled in the universal joint compounds. He did not think Mr. Webber had mentioned the A.S.T.M. method, in which the dark-coloured greases were treated with acid potassium sulphate in place of the ordinary treatment with hydrochloric acid. He had found that method so satisfactory that he had adopted it for all greases, light coloured as well as dark coloured.

He had experienced considerable difficulty, with dark-coloured oils, in getting a very satisfactory acid value by titration methods. He would like to know whether Mr. Webber had had any experience of the electrometric methods which had been used in America in recent years.

THE CHAIRMAN said that he thought that Mr. Hall felt the Americans had been somewhat ignored. It was fitting, therefore, that members should be reminded that the Institute of Petroleum had adopted, wherever possible, the A.S.T.M. standard methods. Consequently, when we referred to the Institute standard methods, we almost automatically referred to the A.S.T.M. standards.

MR. DE WAELE said that his remarks would scarcely be very constructive, as he had no special knowledge of the industry. He would, however, like to take the opportunity of inquiring as to the precise necessity for the measurement of consistency of greases

so far as the exigencies of the trade were concerned. Thus, was it used as a means of mere identification of constants, or as a method of control in manufacture?

He understood that the penetrometer was generally in the form of an instrument in which a cone or cylinder fell into a mass of the grease to be tested, the eventual depth of penetration or velocity of travel over a given depth being recorded as a characteristic. He thought he could assert that if two identical readings were returned from two different greases, it might be quite possible that the greases differed considerably in physical properties, and indeed might recognizably exhibit differences to the touch. This would be accounted for by the fact that the penetrometer was, after all, merely an instrument in which a constant weight was caused to induce an increasing viscous resistance as penetration proceeded: in other words, like a variable stress viscometer. In the case of the penetrometer, the velocity gradient diminished with progressive penetration. Grease being one of that class of substances in which the apparent viscosity diminished with rate of shear, the paths of the two stress/rate-of-shear lines might fortuitously cross. If the recorded point should fall at a crossing point, a recorded but otherwise quite false identity of properties would be registered.

With regard to the question of pre-working, he had examined a sample of grease made in his laboratory by dissolving slaked lime in a mixture of oleic acid and mineral oil, the excess of water being driven off by heat. The resulting grease was a translucent unctuous mass, very homogeneous and smooth. It might have been somewhat different from some commercial greases he had seen, which were often stringy and contained obvious soap crystals. In the grease in question, however, there was no difference in physical properties recorded whether the grease were pre-worked or not, and he attributed this to the fact that the phase responsible for the rigidity of the material, consisted of crystals which were very short in relation to their lengths and, withal, extremely small, and hence did not suffer any appreciable change in orientation on shear. On the other hand, he could quite imagine that in a grease containing rather coarse crystals the effect of pre-working would be to disarrange the crystals, or even break them into shorter units. In the case of the analogous petroleum jelly, which contained rather long, needle-shaped crystals, a great difference of consistency resulted from pre-working; a number of different consistencies might be recorded by pre-working, according to the intensity of the shear produced. The general tendency was for all the differing consistencies to rise to a common level on prolonged storage.

With regard to the application of consistency as a characteristic, he thought the two factors to be considered by the user were the lubricating value or viscosity, and the rigidity of the material. Would it not be possible, for instance, to imagine a material which, under dynamic conditions, would have a sufficiently low viscosity or consistence to lubricate quite adequately, and yet in the static or semi-static condition be too stiff to be forced out of the cup? In other words, one had to deal with two quite unrelated components in the characteristics of such a material as lubricating grease—the dynamic one of viscosity, and the static factor of rigidity, the analysis into which would not be furnished by penetrometer measurements.

He had been rather surprised that the industry had not adopted the more searching method of examination by the capillary plastometer, which would certainly give more illuminating data than did the penetrometer. He had seen published only one paper on capillary plastometric examination of lubricating grease—that by Arveson. He himself had been approached some two or three years ago by (he believed) one of the Ministries on the question of a suggested means for determining the consistency of petroleum greases, and he had submitted a proposition on the basis of the plastometer, which is, after all, only a variable pressure capillary viscometer adapted to handle plastic materials, but evidently the suggestion had not impressed the particular body, as he had heard no further. He might further add that the capillary plastometer has been used in his own practice for the examination of a wide variety of plastic solids, Newtonian, and non-Newtonian fluids, for a great number of years, both as a control and as a research instrument. He had found it to be indispensable for regulating the physical properties of materials, the closeness to standard constants of which he believed were needed to be of far greater stringency than were lubricating greases.

Mr. E. A. Goodchild said that several criticisms had been made of the efforts of those people who drew up specifications. These criticisms were to a large extent justified, but the grease manufacturers had paid too little attention to the study of the

fundamentals of grease constitution, the fibre and gel structures, so that in our present state of knowledge it was impossible to correlate the results of physical tests and chemical analyses embodied in specifications, with the manner in which the greases would function in their intended applications.

Most people put certain chemical limits in their specifications, in the hope that they would get somewhere near the product they had previously found satisfactory, but they had to rely on practical tests to verify that the grease was suitable for their work.

He wished to criticize the method of corrosion testing using copper and steel. Copper was often used, yet it was a very corrosion-resistant metal. He had found that 60/40 brass, which had a duplex structure, was a very much more sensitive metal, being readily attacked by fatty and organic acids, and giving results more in conformity to the attack on bearing metals. The time of 24 hours for the test was very short.

With regard to chemical stability, he did not think there was any comment made in the paper on what the Americans now termed "storage stability" or resistance to oxidation. He would like to direct Mr. Webber's attention to the work of Wright and Lutz on the rate at which oxygen was absorbed when samples of grease were maintained at a certain temperature in an atmosphere of oxygen. In that work the rates of oxygen absorption had been correlated with the chemical storage stability of the grease.

THE CHAIRMAN asked Mr. Goodchild where the work had been published.

MR. GOODCHILD said that it had been published in a paper to the B.E.C. Committee and also in a periodical called "Product Engineering."

THE CHAIRMAN asked whether that was a journal which would normally come within the purview of the members of the Institute.

MR. GOODCHILD said he thought it would; he would let the Institute have the necessary references.

MR. L. O. MASKELL said he would like to add his thanks to Mr. Webber for the excellent paper that had been presented to the Institute that evening. He had not been able to obtain a pre-print of the paper, so that he had some difficulty in co-ordinating in his mind all the factors which Mr. Webber had brought out, but there were two points that he would like to raise.

With regard to the dropping point by the Ubbelohde test, his experience of that method was very satisfactory, particularly with the lower-melting-point greases, which generally had a lime base, and he had been surprised to hear the method condemned by Mr. Chetwin. In the case of soda greases and greases melting at much higher temperatures, he had certainly found some discrepancy in the results, which might be as much as 5° to 10° in the dropping point, but a modification had been brought out some months ago (he forgot who it was that had invented it) in which the grease was scooped out from the inside of the cup with wire, so as to leave a uniform thin layer of grease round the inside of the cup, and by the use of that method it was possible to obtain very consistent results, within 1°, or at the most 2°, of variation.

The other point that he wished to mention was with regard to stability tests. He had been rather surprised to hear Mr. Wilford express satisfaction with the Timken test, because he had found very considerable difficulty in obtaining consistent results with that test. In his view, a test which took into account the bleeding properties of the grease at lower temperatures would be more satisfactory. It seemed to him that the lubricating value of grease was largely determined by the small amount of oil which bled out during service. He thought that, if a test somewhat on the lines of one of those put forward in *Industrial and Engineering Chemistry* (February 1939, Vol. 31, No. 2, pp. 230–235), where a certain weighed quantity of grease was put under a definite pressure and the amount of oil absorbed by a porous plate or a pad of paper was weighed, could be devised and standardized by the Institute, it would be preferable to one of the very severe heating tests. He would like to see such a test put forward by the Standardization Committee.

MR. W. D. DOUGHTY said there was one little point that he would like to make with reference to the time factor in the penetration test at low temperatures. He had found that, particularly in the case of the Air Ministry test on soft greases, a matter of a

few minutes made a considerable difference in the penetration. Consequently a grease might be condemned as not passing the D.T.D. 143 B test because the penetration test had been registered immediately on dropping (within two or three seconds), which one would think would be the normal way of measuring it, instead of waiting for perhaps 30 to 60 seconds, when, if the grease was fairly soft, the weight of the sinker was still causing it to continue its downward path.

Mr. A. Dunbar, referring to the consistency of greases, said that in his opinion the slightest trace of free alkali in a barrel of grease tended to prevent the grease becoming softer in the middle than on the outside.

Mr. G. H. Thornley said he had been very interested in the paper, especially the references to the melting point of greases and their stability at high temperatures. The Ubbelohde melting point was, he thought, quite misleading as a measure of the behaviour at high temperatures. What was required was a standardized test which would measure the degree of softening after exposure to working temperature. There might be two greases, one with a melting point of 400 and the other with a melting point of 330, but, if exposed to a temperature of 300° F. for 3 hours, the grease with the melting point of 400 might still be much softer than the other grease, and even quite fluid.

Mr. D. Clayton said he would like to know how the behaviour in squeezing a grease through the fine clearance of a bearing correlated with the penetrometer test; a similar comparison with the time taken for a rocking journal to sink through a film of grease in the clearance would be of great interest. These were the factors involved in grease lubrication of the chassis of a vehicle relating to the access to the bearings and the rate at which the grease would be squeezed out.

The Chairman asked Mr. Clayton whether his point was not similar to the point brought out by Mr. de Waele with regard to Arveson's work on the rate of shear and its effect on viscosity.

Mr. Clayton said he had not followed that point closely, but the rate of shear would not be great with a slowly rocking journal, even though the clearance was small. There would be the two conditions of well-worked grease, and that after it had been standing for some time. Very different results would be obtained, and it seemed to him that such a test might very much increase the scale of consistency.

Mr. H. L. West said he had used the acetone extraction method, and had found that in some cases it was quite satisfactory, but in other cases oil was extracted from the outer part of the grease, whilst the inner portion remained almost unchanged. The only way to overcome that difficulty was to mix the grease with sand or some such material.

He thought that Mr. Webber's views on the various tests were rather biased by the fact that he was a manufacturer, and that he therefore always knew the constitution of the greases with which he was dealing. A person buying a grease of unknown composition tried to find out something about it, and that made a very big difference, as he was dealing with something of unknown composition.

With regard to the Ubbelohde test of melting point, he thought most people would agree that with lime-base greases it was quite satisfactory. He had found some difficulty in obtaining a glass cup to comply with the specification, particularly with regard to the orifice, and had found metal cups much more satisfactory, as they could be machined to accurate limits.

He thought that a great deal of the variation in melting point and complaint arising therefrom was entirely due to the disregard of the structure of the grease. Lawrence's paper (*J. Instn Petrol. Tech.*, 1938, **24**, 207) on the structure of grease had not apparently been widely read, and he recommended all those present who had not done so to read it. In the case of a soda-base grease, if it separated oils at high temperatures, it might happen that a certain amount of soap would tend to congregate in the orifice and stop the separated oils from filtering through. If, on the other hand, the grease still maintained a uniform structure on heating and melted as a whole—*i.e.*, the soaps

remained in suspension or solution—one would get something more like a true melting point, and not just the temperature of oil separation.

In referring to worked consistency, Mr. Webber had not mentioned block greases. He hoped he did not intend us to determine the worked consistency on these.

With regard to the various tests for stability, he thought most people disregarded the relation of structure to stability. It was necessary to look into the physico-chemical structure of the grease and to see how the stability was related to it, for the very simple reason that one might find two greases of different gel structure which might give satisfactory results in practice, but not in any arbitrary stability test.

Dr. S. Torrance said that, as he was not very happy about the present methods for the analysis of greases, he was very pleased to be able to attend the meeting that evening and to hear Mr. Webber's paper on the subject.

He was interested to hear about Mr. Webber's method of extracting unsaponifiables with acetone, but apparently there was another side to the question, as some of the speakers in the discussion had complained of some difficulty when using acetone, and he felt that Mr. Webber could give enlightenment on one or two of the points raised. As a railway chemist he was very well versed in the book on Standard Methods, where very specific details were given of the amounts to be taken and the volumes to be used. Mr. Webber had not gone into any great detail on those matters, but there were possibly some practical points Mr. Webber might care to add which would be of great use to the analytical chemist.

With regard to specifications, his experience of these was by no means extensive, but he thought they were usually drawn up not on what consumers wanted, but on what manufacturers were able to supply. The consumer tried out the various types of material which were offered, chose the best, and selected that as a specification for his requirements. When he found a better one he modified his requirements accordingly.

Mr. F. J. S. Hall said that the Timken separation test had been criticized, but personally he thought the test was of immense practical value. After all, when a grease broke down under conditions of the test it was usually through dehydration, and in service in the bearing at lower normal working temperatures over a prolonged period the same condition would operate. On the surface it would seem that tests at lower temperatures were of more importance, but he did not think that was altogether the case, as such would not provide sufficient information. In any event, he believed that the two conditions—namely, that of the ball-bearing grease after prolonged service at normal temperatures and that resulting from the tests at high temperatures were correlated—as was also the question of syneresis.

Mr. D. L. Samuel, referring to the consistency of greases, said he thought that some kind of penetration test might be very useful as a works control method, but would probably be of no use in showing how the grease would function in practice. After all, what was required was not a static method, but some method akin to the viscosity determination of a lubricating oil. It seemed to him that an effort should be made to ascertain whether some form of dynamic test could be evolved, so as to obtain some idea of what would happen to the grease when it had to flow.

Mr. R. A. Fraser, referring to the difficulty mentioned by Mr. Hall of obtaining a satisfactory acid value by titration methods in the case of dark-coloured oils, said he had found it very difficult to determine this, and he had substituted as an indicator thymolphthalein, which gave a dark blue colour. The result had been very satisfactory.

Mr. F. J. Burger, speaking with regard to the consistency of greases, said that an instrument had been developed by Dr. C. F. Goodeve to measure anomalous viscosity and thixotropy (*J. Sci. Instr.*, Vol. XVI, No. 1, January 1939). Its principle is similar to that employed in the Couette coaxial cylinder viscometer, the difference being that cylinders are replaced by cones. Thus it is possible to vary the rate of shear within wide limits. It would appear that when using Goodeve's viscometer for measuring the consistency of greases, this would be done under conditions more closely resembling those to which the greases are subjected in practice than when using either penetrometer or plunger type testing apparatus.

THE CHAIRMAN said that he thought members would agree that the principal criticisms in the course of the discussion had been upon the Ubbelohde apparatus and the penetrometer.

Dr. Redgrove would be interested to know that the standardization of the Ubbelohde apparatus for the British Pharmacopœia was necessary for the examination of lards and other comparatively low-melting-point materials used in pharmacy. In our own industry we had to consider the melting points of petrolatums, lime, and soda-soap greases. It was to be hoped that the standardized apparatus would receive sympathetic consideration.

Mr. Maskell was a little uncertain who suggested the scooping out of the grease from the cup in the Ubbelohde test with a wire, so as to leave the grease around the inside of the cup. It was the Shell Development Company of California who made a report on the subject, and sent it to this country for consideration.

Mr. de Waele had referred to Arveson's work. The work of Arveson had been extended by Barnard at the General Discussion on Lubrication in 1937, and by Blott and Samuel (*J. Industr. Engng Chem.*, January 1940). It was therefore quite clear that the subject was still occupying the minds of certain workers. Whether it was a subject which might be standardized was open to discussion.

MR. M. W. WEBBER, in replying to the discussion, said it was quite true that his views on the tests were largely due to the fact that he came from a manufacturing company, and at the beginning of his paper he had said that it was based upon routine work which was concerned largely with the control of works batches, but it must be remembered also with dealing with specifications and samples sent to his company by customers.

He was glad to have Dr. Styles' criticism of the D.T.D. 143.B. method. It was not suggested that that should become a general method, but that it would be a suitable method for development. Probably a combination of that method and the I.P.T. method could be made by fitting the I.P.T. penetrometer with a cylindrical plunger instead of with a cone, because the cone-faces obviously did not allow the viscosity of the oil to have the effect on the penetration that it should have. A plunger going with a constant thrust the whole time would probably give much better results. We had heard a great deal about the pressure-viscosity and rate of shear of lubricating greases, but so far no method of determination had proved capable of standardization from the manufacturers' point of view.

As to the question of acetone extraction, it was not suggested that that was a perfect method, but in the hands of most people it gave more consistent results than the ordinary methods of decomposition. In the case of soda soap Universal Joint Greases, his company certainly had trouble, largely due to the asphaltic content of the oil; they were investigating different solvents, and in all probability something of a higher boiling point would give better results. As to using toluene for the final extraction of the lime soap, lime soap would not be affected by most solvents, but toluene completely extracted it very rapidly. The boiling point of toluene was 300° F., and the temperature in the apparatus became so high that the solvent was always on the point of boiling round the thimble. If something like that could be found for soda-soap greases a much more rapid extraction would be obtained.

With regard to the Timken test, it was not suggested that a heat test which involved dehydration of lime-soap greases had no use, but stability at working temperatures was more important. The Timken test depended largely on the manipulation and the filling of the grease into the tube after dehydration in the cup.

With regard to the question of heat stability tests at temperatures below 200° F., there was some correlation in service when the stability test was carried out for lengthy periods.

Mr. West had commented on the structure of grease in the Ubbelohde apparatus. He thought that was the whole crux of the question as to the varying results obtained with soda-soap lubricants. Soda-soap grease could have a structure ranging from smooth non-fibrous to a heavy fibre, and the heavier the fibre the more oil was separated. Sometimes the oil drips from the cup giving a low apparent dropping point, whilst sometimes the heavy fibre clogs the orifice, thus giving too high a reading.

With regard to Mr. Maskell's suggestion that the bleeding or syneresis of oil from grease was of importance, that was a matter of doubt, because one got very useful lubrication with the Timken machine in particular before there was any separation of

oil at all. Further, the difficulty in standardizing such a test was that, while in the laboratory a grease might release 1 per cent. of oil in a given period, there would in all probability be continued separation of the oil and breakdown of the grease in service or in storage.

As to the variation in consistency throughout a barrel of grease when drawn from a mixer, the question of avoiding that was largely one of improvements in manufacture, and not in testing, and the sampling was therefore important.

He was deeply indebted to Mr. Evans, who had given him a great deal of help and advice in the preparation of the paper.

THE CHAIRMAN, in expressing the thanks of the Institute to Mr. Webber for his admirable paper, said the large attendance at the meeting was evidence of the interest taken in Mr. Webber's paper, and in the subject of standardization of grease tests.

OCTANE RATINGS OF A NUMBER OF PURE HYDROCARBONS AND OF SOME OF THEIR BINARY MIXTURES.*

By J. Smittenberg, H. Hoog, B. H. Moerbeek, M.Inst.Pet., and M. J. v. d. Zijden.

Summary.

C.F.R.–A.S.T.M.-Motor method octane numbers have been determined of fifty hydrocarbons, the majority of which were in a very pure state. In addition the octane numbers of some binary hydrocarbon mixtures are given, and a method is described by means of which the octane numbers below zero and above 100 were estimated.

1. Introduction.

As the requirement of high octane fuels for aeroplane engines is still increasing, a knowledge of the behaviour in the engines of individual hydrocarbons of high octane number, becomes more and more important.

Much is known already about the octane numbers of the individual hydrocarbons. Reference may be made to the paper of Lovell and Campbell [1] in which the most important literature on this subject is cited. As a rule only small quantities of the hydrocarbons investigated were available. Their "octane rating" was therefore very often carried out on blends with other hydrocarbons or gasolines or in a small engine which differed markedly from the standardized C.F.R.-engine.

The publication of the octane numbers of fifty individual hydrocarbons, which we were able to determine in an accurate way by the standardized C.F.R.–A.S.T.M.-Motor method, may therefore be of value.

2. Preparation and Purification of the Hydrocarbons.

The majority of the hydrocarbons used were prepared synthetically. A description of their preparation and purification has been published in the "Recueil des Travaux Chimiques des Pays-Bas." [2]

As a rule a quantity of 2 kg. was prepared and purified by rectification. A small part of this quantity was purified further for the purpose of the determination of the physical constants. As this extreme purification was not necessary for the octane-number determinations, the latter have been carried out with preparations of a somewhat inferior purity.

For purposes of comparison the physical properties of the sample used for octane rating are quoted in the table, together with the properties of the purest available sample. *Unless otherwise stated the purity of the sample used for octane rating is at least* 98 *per cent.*

The origin of the hydrocarbons the preparation of which is *not* described in the above-mentioned paper is as follows.

Methane was obtained commercially and analysed by means of Podbielniak distillation; purity 99 per cent.

Ethene was prepared by dehydration of ethylalcohol ;

* Paper received 3rd November, 1939.

Ethane by hydrogenation of the ethene obtained. The purity of the ethene was only 91 per cent., that of the ethane 95 per cent.

Propane, n-*butane*, and 2-*methylpropane* were separated from natural gas by fractionation; purity 98–99 per cent.

Dimethylpropane (tetra-methyl-methane) was prepared synthetically by condensation of methylchloride and *tert.*-butylchloride; purity 95 per cent.

2 : 3 : 4-*Trimethylpentane* was prepared by isomerization of 2 : 4 : 4-trimethylpentene (di-isobutene) with the aid of phosphoric acid as catalyst, followed by hydrogenation and rectification of the product; the purity is estimated to be about 90–95 per cent.

2 : 2 : 3 : 3-*Tetramethylbutane* (hexa-methyl-methane) was prepared synthetically by condensation of *tert.*-butylchloride; purity > 98 per cent.

Propene was prepared by dehydration of sec.-propylalcohol; purity about 95 per cent.

The *olefines* n-*pentene* up to 2 : 4 : 4-*trimethylpentene* were obtained as intermediate compounds in the preparation of the corresponding paraffins; they may be contaminated with isomers, in which the position of the double bond is different. The content of olefines of the indicated carbon skeleton in each sample is at least 95 per cent.

Hexadiene-2-4 was prepared synthetically from crotonaldehyde.

The product obtained is a mixture of different isomers; total amount of hexadienes-2-4 estimated to be about 90 per cent.

Benzene and *toluene* were obtained commercially; purity > 98 per cent.

3. Determination of the Octane Number.

The octane numbers were determined according to the C.F.R.–A.S.T.M.-Motor method using *n*-heptane and *iso*-octane as reference fuels.

For the extrapolation of the octane scale below zero and above 100, the following method was applied.

Using a 65/35 blend of *iso*-octane/*n*-heptane and standard adjustment of the bouncing pin, the height of the compression chamber (= micrometer reading + 0·500″) was measured at standard knock intensity (knockmeter reading 50). The same was done for 0/100, 40/60, 60/40, 80/20, and 100/0 blends of *iso*-octane/*n*-heptane. The heights of the compression chamber measured were plotted against the octane number of the blend. The curve obtained appears to be in good agreement with the empirical formula

$$O = \frac{1{\cdot}369 - H}{1{\cdot}954 - H} \cdot 178$$

as is shown in the following table :—

(O = octane number of the blend;
H = height of the compression chamber in inches.)

H (measured).	O_m (measured).	O_c (calculated).	$O_m - O_c$.
1·375	0	− 1·8	+ 1·8
1·200	40	39·9	+ 0·1
1·070	60	60·2	− 0·2
1·035	65	64·7	+ 0·3
0·885	80	80·6	− 0·6
0·620	100	99·9	+ 0·1

According to the above-mentioned formula the curve was extrapolated below zero and above 100; see Fig. 1. As an interesting point in this extrapolation method it may be mentioned that the octane number of an "absolutely knock-free hydrocarbon" appears to be 125.

In this way the height of the compression chamber for the hydrocarbons methane, ethane, 2 : 2 : 3-trimethylbutane, *n*-octane, 2 : 2 : 3-trimethylpentane, *n*-nonane, benzene and toluene was measured and used as a basis for the calculation of their octane number.

For the supply of gaseous and of very volatile hydrocarbons a special arrangement was used consisting of a bomb with Hofer needle-valve connected with the intake silencer of the carburettor.

4. Discussion on the Octane Numbers of the Pure Hydrocarbons.

In the *paraffin series* methane is undoubtedly the hydrocarbon with the highest octane number. The octane numbers of the normal paraffins decrease regularly with increasing chain length. Branching of the chain increases the octane number (an exception is dimethylpropane with a lower octane number than 2-methylbutane); other correlations between structure and octane number seem hardly to be justified by the available material.

Among the liquid paraffin hydrocarbons there are only two which have a higher octane number than 2 : 2 : 4-trimethylpentane, namely 2 : 2 : 3-*trimethylbutane* and 2 : 2 : 3-*trimethylpentane*. The highly branched 2 : 2 : 3 : 3-tetramethylbutane is a solid substance with a melting-point of + 101·5° C.

The dispersion among the octane numbers of the *olefines* is much less than among the paraffins. Some of them, *e.g.*, ethene, propene and some strongly branched olefines have lower octane numbers than the corresponding paraffins, whereas the octane number of others, *e.g.*, *n*-pentene, *n*-hexene, *n*-octene, 3-methylheptene and others is lowered on hydrogenation.

The octane numbers of the *naphthenes* investigated give an indication that the five-ring naphthenes may have higher octane numbers than the four- and six-ring naphthenes with the same number of carbon atoms.

The octane numbers of the *aromatics* investigated are above 100; the reproducibility of the octane number of pure benzene was unsatisfactory; on different days it spread between 103 and 110. The real octane number of benzene is probably much higher; see also Section 5 of this paper.

5. Octane Numbers of Binary Hydrocarbon Mixtures.

In addition to the octane numbers of the pure hydrocarbons we determined also the octane numbers of several hydrocarbon mixtures; partly to verify the applied extrapolation method of the octane scale, partly to get some insight into the "blending value" of the different hydrocarbons. The results are plotted in Figs. 2–8.

Figs. 2, 3, and 4 are octane number curves of binary paraffin mixtures; the greater part of these curves show only minor deviations from a straight line.

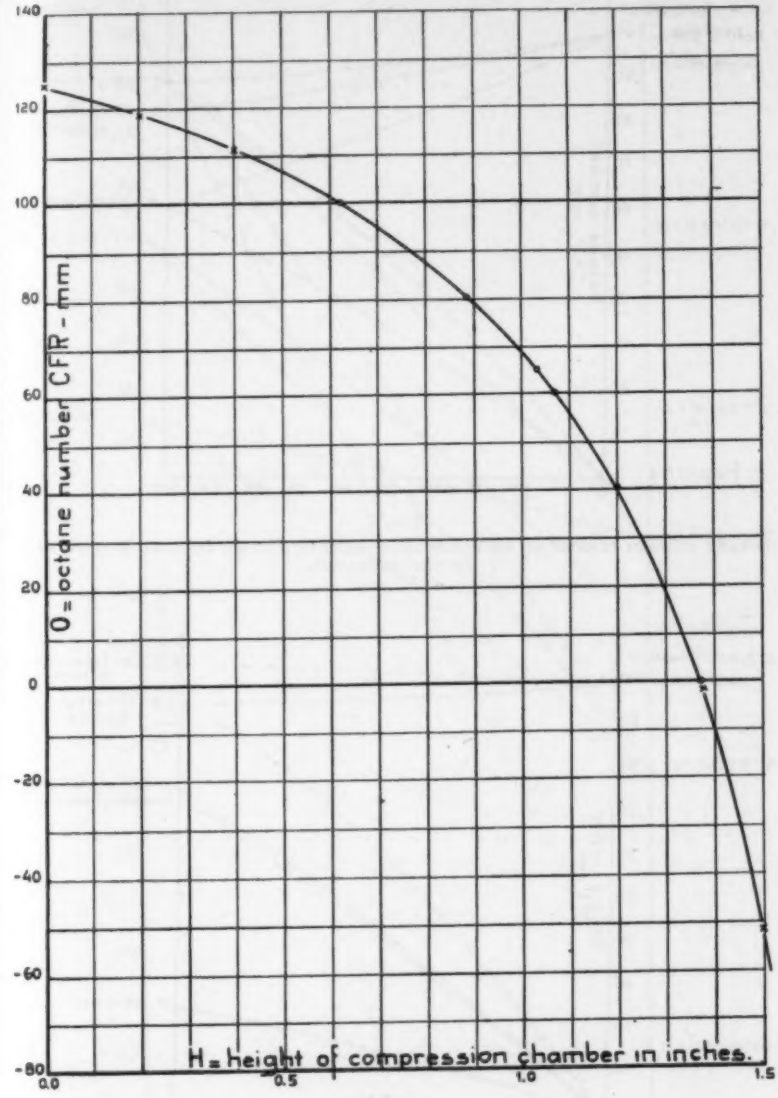

FIG. 1.

EXTRAPOLATION CURVE FOR OCTANE NUMBERS ABOVE 100 AND BELOW ZERO.

o = Observed.
x = Calculated according to the formula

$$O = \frac{1{\cdot}369 - H}{1{\cdot}954 - H} \cdot 178.$$

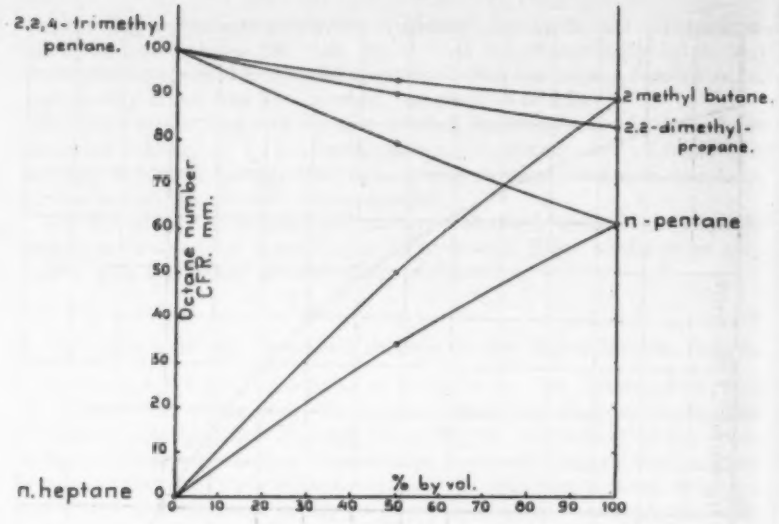

FIG. 2.

OCTANE NUMBER CURVES OF MIXTURES OF *n*-HEPTANE AND OF *iso*-OCTANE WITH EACH OF THE PENTANES.

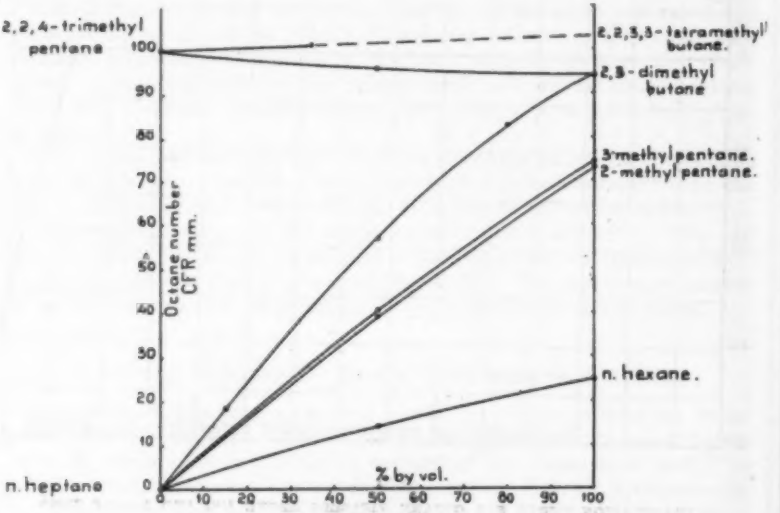

FIG. 3.

OCTANE NUMBER CURVES OF MIXTURES OF *n*-HEPTANE AND OF *iso*-OCTANE WITH VARIOUS PURE PARAFFINS.

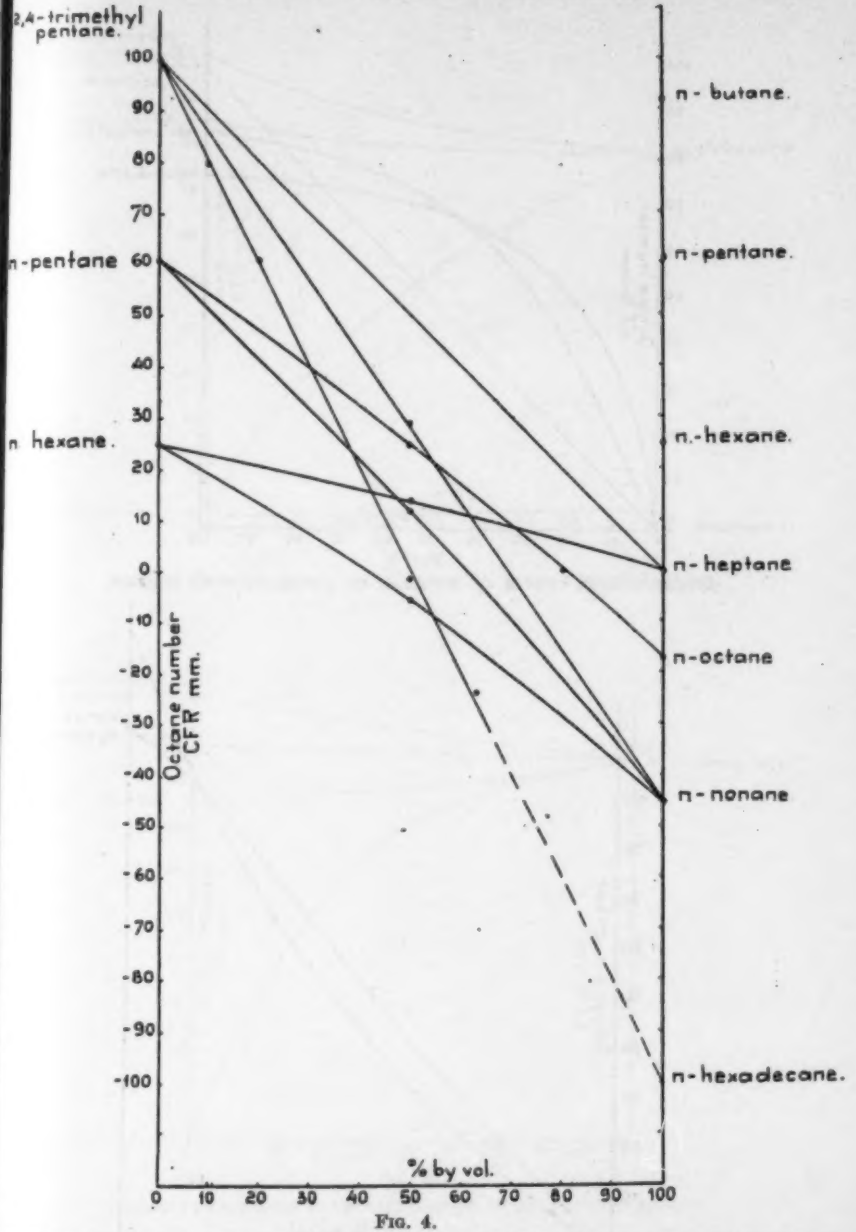

FIG. 4.

OCTANE NUMBER CURVES OF MIXTURES OF STRAIGHT-CHAIN PARAFFINS WITH STRAIGHT-CHAIN AND WITH BRANCHED PARAFFINS.

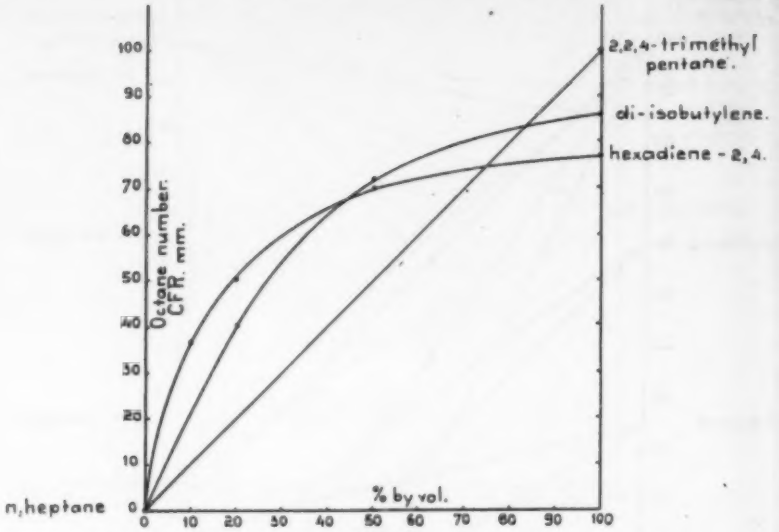

FIG. 5.

OCTANE-NUMBER CURVES OF MIXTURES OF *n*-HEPTANE WITH OLEFINS.

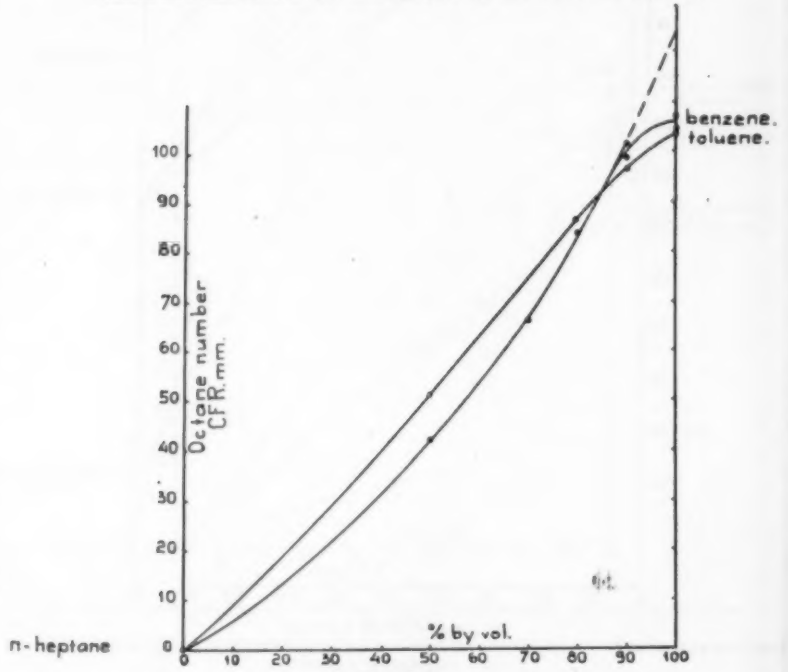

FIG. 6.

OCTANE-NUMBER CURVES OF MIXTURES OF *n*-HEPTANE WITH AROMATICS.

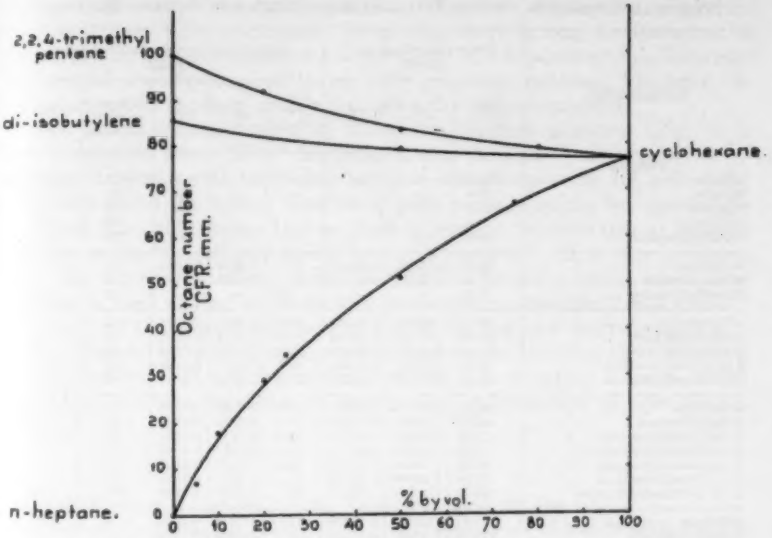

FIG. 7.

OCTANE-NUMBER CURVES OF MIXTURES OF VARIOUS HYDROCARBONS.

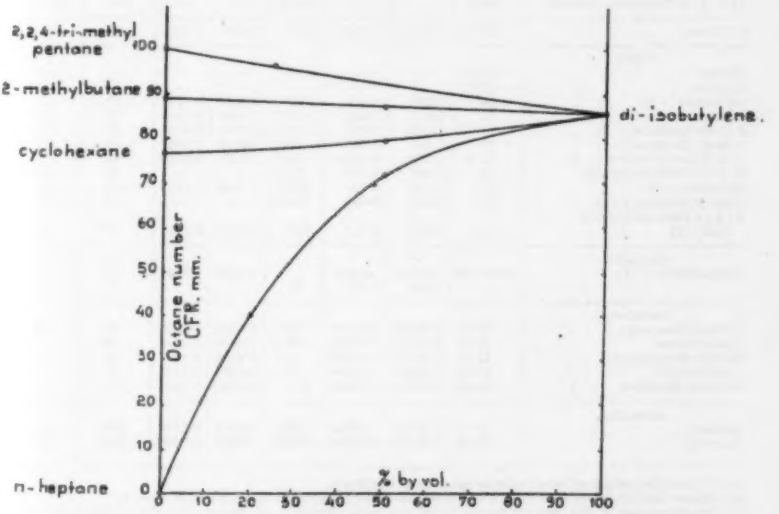

FIG. 8.

OCTANE-NUMBER CURVES OF MIXTURES OF VARIOUS HYDROCARBONS.

PHYSICAL CONSTANTS OF THE HYDROCARBONS USED FOR OCTANE RATING.

HYDROCARBON.	Properties of purest sample.			Properties of sample, used for octane rating.				
	B.p. (760 mm.), °C.	n_D^{20}.	d_4^{20}.	B.p. (760 mm.), °C.	n_D^{20}.	d_4^{20}.	Octane number A.S.T.M.	REMARKS.
Paraffins.								
Methane	−161·58	—	—	—	—	—	110	(1), (2)
Ethane	− 88·5	—	—	—	—	—	104	(1), (2)
Propane	− 42·2	—	—	—	—	—	100	(1)
n-Butane	− 0·5	—	—	—	—	—	92	(1)
2-Methylpropane	− 12·2	—	—	—	—	—	99	(1)
n-Pentane	35·95	1·35764	0·62634	36·0	1·3580	0·6263	61	
2-Methylbutane	27·80	1·35391	0·61973	27·8	1·3552	0·6198	89	
Dimethylpropane	9·45	—	—	9·6	—	—	83	(1)
n-Hexane	68·75	1·37494	0·65943	68·8	1·3751	0·6589	25	
2-Methylpentane	60·30	1·37151	0·65316	60·3	1·3714	0·6525	73	
3-Methylpentane	63·30	1·37657	0·66435	63·2	1·3766	0·6638	75	
2 : 2-Dimethylbutane	49·70	1·36852	0·64919	49·7	1·3691	0·6489	96	
2 : 3-Dimethylbutane	58·05	1·37504	0·66166	58·1	1·3752	0·6617	95	
n-Heptane	98·40	1·38770	0·68378	98·4	1·3878	0·6835	0	
2-Methylhexane	90·10	1·38493	0·67869	90·1	1·3852	0·6782	45	
2 : 2-Dimethylpentane	79·30	1·38231	0·67388	79·3	1·3822	0·6734	93	
2 : 3-Dimethylpentane	89·80	1·39205	0·69514	89·8	1·3921	0·6944	89	
2 : 4-Dimethylpentane	80·60	1·38148	0·67275	80·6	1·3820	0·6723	83	
3 : 3-Dimethylpentane	86·10	1·39092	0·69320	86·1	1·3911	0·6926	84	
2 : 2 : 3-Trimethylbutane	81·00	1·38949	0·69007	81·0	1·3899	0·6898	101	(3)
n-Octane	125·75	1·39765	0·70280	125·8	1·3979	0·7026	−17	(3)
3-Methylheptane	119·05	1·39851	0·70584	119·1	1·3988	0·7065	35	
2 : 3-Dimethylhexane	115·80	1·40131	0·71234	115·8	1·4015	0·7118	76	
2 : 5-Dimethylhexane	109·25	1·39281	0·69426	109·3	1·3930	0·6943	52	
3 : 4-Dimethylhexane	117·85	1·40431	0·71951	117·9	1·4044	0·7195	85	
2 : 2 : 3-Trimethylpentane	110·05	1·40297	0·71613	110·1	1·4032	0·7162	102	(3)
2 : 2 : 4-Trimethylpentane	99·10	1·39146	0·69196	99·1	1·3917	0·6920	100	
2 : 3 : 4-Trimethylpentane	113·4	1·4046	0·7195	113·8	1·4045	0·7197	97	(1)
3-Methyl-3-ethylpentane	118·35	1·40785	0·72742	118·4	1·4081	0·7270	91	
2 : 2 : 3 : 3-Tetramethylbutane	106·5	—	—	106·5	—	—	103	(1), (3)
n-Nonane	150·70	1·40556	0·71808	150·7	1·4060	0·7165	−45	(3)
Olefins.								
Ethene	−102·4	—	—	—	—	—	81	(1)
Propene	− 47·7	—	—	—	—	—	85	(1)
n-Pentene (−2)	36	1·380	0·649	36·4	1·3802	0·6498	80	(1)
n-Hexene (−2)	68	1·397	0·685	67·6	1·3950	0·6800	78	(1)
2-Methylpentene (−2)	66	1·3984	0·693	67·4	1·3997	0·6870	78	(1)
3-Methylpentene (−2)	68	1·400	0·695	69·5	1·4032	0·6956	79	(1)
2 : 2-Dimethylbutene (−2)	41·2	1·3766	0·6519	41·5	1·3769	0·6530	94	(1)
2 : 2 : 3-Trimethylbutene	78	1·402	0·7029	77·8	—	—	89	(1)
n-Octene (−2)	125	1·412	0·720	124·6	1·4142	0·7204	55	(1)
3-Methylheptene (−2)	122	1·418	0·730	122·0	—	—	74	(1)
2 : 4 : 4-Dimethylpentene (−1 and −2)	103	1·412	0·719	100	1·4108	0·719	86	(1)
Di-Olefins.								
Hexadiene (−2 : 4)	about 80	about 1·447	about 0·717	80	1·4479	0·7182	77	(1)
Naphthenes.								
Ethylcyclobutane	70·70	1·40209	0·73787	70·7	1·4023	0·7376	68	(4)
Cyclopentane	49·20	1·40644	0·74542	49·2	1·4065	0·7459	83	
Methylcyclopentane	71·85	1·40978	0·74869	72·0	1·4102	0·7484	82	
Cyclohexane	80·80	1·42625	0·77867	80·8	1·4262	0·7783	77	
Methylcyclohexane	100·80	1·42305	0·76944	110·3	1·4230	0·7689	71	
Aromatics.								
Benzene	80·10	1·50123	0·87896	80·1	1·5011	0·8786	108	(1)
Toluene	110·68	1·49685	0·86697	110·8	1·4962	0·8666	104	(1)

(1) Physical properties of purest sample taken from literature.
(2) Octane number determined by extrapolation according to the method described in Sect. 2.
(3) Octane number of the pure compound which is a solid substance, calculated from the octane number of a blend of 35 per cent. by weight of the compound and 65 per cent. by weight of 2 : 2 : 4-trimethylpentane (octane number of the blend 101).
(4) Octane number of the pure compound, which was not available in sufficient quantity, calculated from the octane number of a blend of 50 per cent. by vol. of the compound and 50 per cent. by vol. of *cyclo*hexane (octane number of the blend 72·5).

Fig. 5 illustrates clearly the peculiar behaviour of mixtures of olefines and di-olefines with *n*-heptane. From this curve it can, for instance, be seen that the octane number of a 50/50 blend of *n*-heptane and di-isobutene is lowered twenty-two points on hydrogenation, whereas the pure di-isobutene gains fourteen octane points by the same treatment.

The octane number curve of *n*-heptane–benzene mixtures (Fig. 6) is not a straight line. The "blending octane number" of benzene in *n*-heptane increases with increasing benzene content up to 90 vol. per cent.; from this curve the octane number of pure benzene might be expected to be about 125; that means that in these *n*-heptane–benzene blends benzene behaves as an "absolutely knock-free hydrocarbon." It is very probable that the "knock" which occurs at high compression ratios when pure benzene is used as the fuel is another phenomenon than the "real knock" ("pink") of the other hydrocarbons and of the heptane–benzene blends.

Figs. 7 and 8 are added merely to stress again the fact that the "blending octane number" of a hydrocarbon is useless if no mention is made of the basis-fuel and the quantity in which the hydrocarbon in question is blended.

References.

[1] Lovell, W. G., and Campbell, J. M., *Chem. Rev.*, 1936, **22**, 159.
[2] Wibaut, J. P., Hoog, H., Langedijk, S. L., Overhoff, J., and Smittenberg, J., *Rec. Trav. chim. Pays-Bas*, 1939, **58**, 329–77.

TWENTY-SIXTH ANNUAL REPORT,

1939.

THE Twenty-Sixth Annual Report of the Council covering the activities of the Institute during 1939 is presented for the information of the members.

MEMBERSHIP.

The changes in membership which occurred during 1939, and the total membership of all classes on 31st December, 1939, are summarized in the Table below :—

	Total Dec. 31, 1938.	Changes during 1939. New.	Transferred to.	Re-signed.	De-ceased.	Transferred from.	+ or −	Total Dec. 31, 1939.
Hon. Members.	20	—	—	—	—	1	− 1	19
Fellows . .	—	26	381	—	1	—	+406	406
Members .	736	57	96	18	6	349	−220	516
Assoc. Mems. .	626*	54	38	15	2	155*	− 80	546
Students .	96	46	—	2	—	10	+ 34	130
Totals .	1478	183	515	35	9	515	+139	1617

* Associate Members and Associates.

The Council has to record with deep regret the decease of the following members during 1939 :—

	Date elected.	Class of membership.
BARTON, D. C.	1926	Fellow.
BUERGER, C. G.	1922	Member.
CURRIE, J. L.	1936	Member.
FULLER, H. S.	1924	Associate.
GIBSON, G. W. E.	1920	Fellow.
JENKIN, C. O. F.	1924	Member.
MACKENZIE, W. L.	1920	Member.
PEARCE, E. A.	1925	Associate.
WHEELER, R. V.	1925	Member.

RE-CLASSIFICATION OF MEMBERSHIP.

A Special General Meeting was held on 10th January, 1939, to approve temporary regulations for the transfer of Members, Associate Members, and Associates under the former constitution of the Institution of Petroleum Technologists, to the classes of Fellow, Member, and Associate Member of the Institute of Petroleum.

These temporary regulations were forwarded to every member. They were to be in force up to 30th June, 1939, but in practice the Council has dealt with applications received up to the end of the year. A total of 540 applications were received. Every application was given individual con-

sideration by the Election Committee, and the qualifications of each candidate assessed in relation to the definitions of the three categories of membership introduced in 1938.

The net result of the re-classification of membership is shown in the Table given above. The total increase of membership of 139 during the year is regarded by the Council as very satisfactory, although it must be qualified by the observation that no names were removed from the roll of the Institute during 1939 by reason of non-payment of subscriptions. Owing to the international situation remittances from members abroad were in many cases impossible, and the provisions of the By-Laws were not exercised.

Honours.

William Fraser, Esq., C.B.E. (Fellow), was created a Knight Bachelor in the Birthday Honours List, 1939.

Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S. (Past-President), was awarded the Albert Medal of the Royal Society of Arts in June, 1939.

Representation on Other Bodies.

The Institute has been officially represented on the following bodies :—

The American Society for Testing Materials : Lt.-Col. S. J. M. Auld, Dr. A. E. Dunstan, Dr. F. H. Garner, and Mr. J. Kewley (Honorary Members of Committee D-2 on Petroleum Products and Lubricants).

The British National Committee of the World Power Conference : Dr. A. E. Dunstan.

The Technical Committee of the Chemical Engineering Conference : Lt.-Col. S. J. M. Auld.

The British Standards Institution, Petroleum Industry Committee : Lt.-Col. S. J. M. Auld, Prof. J. S. S. Brame, Dr. A. E. Dunstan, Mr. B. J. Ellis, Dr. F. H. Garner, Mr. J. Kewley, and the Secretary.

The Permanent Council of World Petroleum Congresses : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, and the Secretary.

XVIIIth International Geological Congress : The President and Mr. T. Dewhurst.

Diesel Engine Users Association : Mr. L. J. Le Mesurier and Mr. N. Mitchell.

Ramsay Memorial Laboratory : Mr. J. Kewley.

Permanent International Association of Road Congresses : Dr. P. E. Spielmann.

Parliamentary Science Committee : Lt.-Col. S. J. M. Auld, Mr. T. Dewhurst, Dr. E. R. Redgrove.

S.A.E. World Automotive Engineering Congress : Dr. A. E. Dunstan and Mr. N. Mitchell.

Viscosity Conference of Société Belge pour l'Étude du Pétrole : Dr. F. H. Garner, Dr. G. Barr, and the Secretary.

The Institute has also been represented on numerous Sub-Committees of the British Standards Institution.

Benevolent Fund.

The audited statement of Receipts and Payments of the Benevolent Fund during 1939 is submitted below. The receipts from all sources were £76 6*s.* 5*d.*, as compared with £106 18*s.* 4*d.* in 1938.

Contributions to the Fund during 1939 were received from the following members, to all of whom the Council expresses its grateful thanks :—

Adams, A. C.
Andrews, B. G.
Auld, S. J. M.
Beavan, A. M. E.
Bell, O. A.
Blakiston, J. H.
Bolton, R. P.
Brame, J. S. S.
Brayfield, T. H. G.
Bressey, R. J.
Brodie, N. M.
Cameron, I.
Charlton, H. E.
Clement, L.
Clifford, G.
Cohn, T.
Cole, F. A. J.
Cox, A. W.
Crichton, R.
Dalley, C.
Downs, W. W.
Dunkley, G. W.
Dunstan, A. E.
Edeleanu, I.
Evans, R. J.
Everist, G. E.
Fay, E.
Ferguson, B. C.
Frewing, J. J.
Griffiths, P. M.
Henson, F. R. S.
Higgs, P. G.
Hills, S. R.
Jackson, J. S.
Jameson, J.
Kewley, J.
Mackilligan, R. S.
Masters, J. S. S.
McCreath, T. T.
Le Mesurier, L. J.
Moon, C. A.
Nash, A. W.
Owen, A. G.
Parr, R. W.
Parrish, J.
Perks, A. J.
Porter, P. N. D.
Purdie, A. C.
Purves, A. R.
Redgrove, E. R.
Richards, G. A.
Sams, C. E. R.
Sanders, J. McConnell.
Schlumberger, M.
Smallwood, W.
Smith, A. F. P.
Southwell, C. A. P.
Spielmann, P. E.
Taitt, G. S.
Taylor, T. M.
Tullett, G. V.
Tweed, R. R.
Walsh, D. M.
Walter, G.
Wood, C. W.
Young, J. H. M.
Shell Marketing Company, Central Laboratories.

Whilst the calls on the Fund have fortunately been few in the past, they are likely to increase as time goes on. The Council earnestly appeals to all members to support their own Benevolent Fund more generously. It is pointed out that the total received by way of subscriptions and donations (£52 10*s.* during 1939) represents an average contribution of about eightpence per member.

Premises.

The outbreak of war caused serious dislocation to the work of the Institute. Early in September 1939 the Institute's new offices at the Adelphi were requisitioned by H.M. Office of Works for occupation by a Government Department. In the few days available it was not possible to find suitable alternative accommodation in the London district.

Professor A. W. Nash, on behalf of the University of Birmingham, generously offered accommodation at the Department of Oil Engineering and Refining, The University, Birmingham. The Council was pleased to accept this offer, and expresses its appreciation of the facilities which have been placed at the disposal of the Institute and its staff. Whilst the disadvantages of removal from London are obvious, the transfer to Birmingham has given the Institute the compensating advantage of association with one of the leading centres of petroleum education and research.

A large part of the furniture at the Adelphi, much of it new, was also requisitioned by H.M. Office of Works. Some of the furniture was stored; other items were removed to Birmingham. The question of compensation to the Institute under the provisions of the Compensation (Defence) Act, 1939, is still under consideration.

Finance.

The audited Revenue Account for the year and Balance Sheet as at 31st December, 1939, are given below. Items of the year's expenditure

calling for particular observation are those relating to "Rent and Rates" and "Removal and Other Expenses in connection with the requisitioning of the Adelphi." The full year's rent and rates, amounting to £2808 19*s.* 4*d.*, have been shown on the Revenue Account. This amount has been paid in full in accordance with the Institute's lease, together with the first quarter's rent for 1940, paid in advance at Christmas 1939, notwithstanding the fact that the Institute did not have the use of its Adelphi premises after September 1939. No credit has been taken for any compensation which may ultimately be received from H.M. Office of Works, since no indication of the amount of such compensation had been made prior to 1st May, 1940. The item "Removal and Other Expenses," which includes certain provisions for senior members of the staff transferred to Birmingham, is also the subject of a claim to H.M. Office of Works.

The Council cannot but view the uncertainty of the present position with some concern and, in co-operation with the Institute's solicitors, is maintaining constant watch on a difficult situation.

A considerable reduction of income during 1940 will be inevitable, but economies in administration have been introduced since September 1939 whereby the Council hopes in part to off-set the loss of revenue.

National Service Register.

At the request of the Ministry of National Service and Labour, the Council authorized the issue in April 1939 of registration cards for the Central Register. The object of this register is to make available to H.M. Government a record of persons with scientific, technical, and administrative qualifications. Registration cards were issued to all Fellows, Members, and Associate Members in the United Kingdom; and to members of British nationality in certain other countries.

About 450 cards were returned out of a total of 700 issued to members in the United Kingdom. In view of the large number of members of the Institute who had completed registration cards for other scientific societies, this total is regarded as very satisfactory. One set of the cards is filed at the Ministry of National Service and Labour; a duplicate is retained at the Institute's offices.

An Oil Sub-Committee of the committee appointed by the Ministry of National Service to deal with mining and metallurgy was formed in March 1939. Mr. J. Kewley was invited by the Ministry of Labour to act as Chairman of this Oil Sub-Committee. Dr. F. B. Thole, Mr. S. E. Coomber, and the Secretary are also members. Regional Panels were established at twelve provincial centres, and many members of the Institute have consented to serve on these Panels.

Meetings of the Institute.

Four Ordinary Meetings of the Institute and the Annual General Meeting were held in London during 1939. In addition, special conferences were held on "Dangerous Gases" in London, and on "Fuels and Lubricants" in Birmingham, to which reference is made below.

The subjects of Papers presented at the Ordinary Meetings and at

meetings of specialised Groups during the year 1939 are given in the following Table :—

Date. 1939.	Subject.	Authors.
10th Jan.	Special General Meeting *re* Temporary By-Laws.	
	"Tank Strapping."	P. Kerr.
14th Feb.	"Some Factors in Oil Accumulation."	V. C. Illing.
14th March.	"Dangerous Gases in the Petroleum and Allied Industries."	Various.
27th April.	Annual General Meeting.	
	"Control of Oil Fires."	A. F. Dabell.
22nd–24th May.	Birmingham Conference.	Various.
	Asphaltic Bitumen Group.	
28th March.	"Measurement of Flow Properties of Bitumens."	D. C. Broome.
9th May.	"Bitumen Emulsions."	L. G. Gabriel.
21st Nov.	Exhibition of Films on Asphalt Mastics.	G. J. Hancock.
	Lubrication Group.	
23rd Feb.	"High-Tension Piston Rings."	W. A. Wilson.

The average attendance at these Meetings (excluding the Birmingham Conference) was 70. This is lower than the average for 1938 (98).

Branch Lecture.

Mr. G. W. Lepper, A.R.C.S., B.Sc., Technical Adviser, H.M. Petroleum Department, delivered the Branch Lecture on "The Search for Oil in Britain" to members of Branches in Great Britain, as follows :—

27th January	at Swansea.
16th February	at Glasgow.
9th March	at Manchester.
10th March	at Birmingham.

Conference on "Dangerous Gases."

A series of Papers on "Dangerous Gases in the Petroleum and Allied Industries" was discussed at a whole-day meeting of the Institute, held in London on Tuesday, 14th March, 1939.

Mr. W. W. Goulston, B.A., B.Sc., A.I.C. (Fellow), acted as organizer of the meeting on behalf of the Council.

Mr. A. R. Stark, B.Sc. (Fellow), acted as General Reporter for the meeting and presented a summary of the Papers at each Session.

This was probably the first occasion on which so much valuable but dispersed information relating to the detection, toxicity, and protection against inflammable and poisonous gases had been assembled at one conference. Papers were received from petroleum companies in Great Britain, Holland, and U.S.A., the Safety in Mines Research Board, the Chemical Defence Research Station, the Chemical Research Laboratory, and the University of Leeds. They were published in two special issues of the *Journal* in May and June 1939, and have also been reprinted and published by the Institute as a book.

In connection with the Conference an exhibition of apparatus and models, loaned by various Government Departments and companies, was held at the Institute's offices, The Adelphi, W.C. 2, from 13th to 25th March, 1939. The exhibits were arranged by Mr. C. L. Gilbert, B.Sc., A.R.C.S. (Member).

Charts and photographs from the Exhibition were subsequently presented on permanent loan to the Home Office Industrial Museum, Horseferry Road, London, S.W. 1.

Birmingham Conference on Fuels and Lubricants.

The 1939 Summer Meeting of the Institute was held in Birmingham on 22nd–24th May, 1939. It provided an opportunity, of which full advantage was taken, for technologists engaged in the petroleum and automobile industries to meet and discuss problems of mutual interest, relating to fuels and lubricants for internal-combustion engines. The Conference was attended by about 250 members of the Institute of Petroleum, the Institution of Automobile Engineers, and other scientific and technical bodies in this country and abroad.

Four Sessions were held for the presentation and discussion of Technical Papers, presided over by :—

The President (Prof. A. W. Nash).
Capt. G. E. T. Eyston, M.C.
Dr. D. R. Pye, F.R.S. (representing the Royal Aeronautical Society).
F. G. Woollard, Esq., M.B.E. (President-Elect, The Institution of Automobile Engineers).

Sixteen Papers were presented. These were published with the ensuing discussion in the *Journals* of September–December 1939. Two of these Papers were also presented to the World Automotive Engineering Congress organized by the S.A.E. in New York and opened in New York on 22nd May.

Included among the Papers presented at Birmingham was a Report of the Knock-Rating Committee of the Institute on "The Development of Fuels for Automobile Engines." This was published both in the May 1939 issue of the *Journal* and in the June 1939 issue of the *Journal of the Institution of Automobile Engineers*.

On May 23rd a Reception by the Lord Mayor of Birmingham (Alderman James Crump), the Pro-Chancellor (Mr. E. P. Beale, M.A.), and the Vice-Chancellor (Dr. R. E. Priestley, M.A.) was held in the Great Hall of the University, Edgbaston. The various engineering departments of the University were opened to the inspection of the visitors.

On 24th May a Dinner was held at the Grand Hotel, Birmingham. Speeches were made by the Lord Mayor, Dr. Priestley, Mr. C. A. P. Southwell, and the President. During the course of the dinner the Empire Day Speech of H.M. the King was relayed from Ottawa. The Dinner was followed by a Dance.

Visits were made on the afternoon of the 24th May to the works of the

Austin Motor Company, Ltd., and Morris Commercial Cars, Ltd., both companies entertaining their visitors to luncheon.

An interesting programme of excursions for ladies attending the Meeting included visits to Cadbury Bros., Ltd., Harry Vincent, Ltd., and Warwick Castle.

The Council expresses its grateful appreciation of the organization of this Meeting by the members of the Reception Committee (Messrs. W. E. Aylwin, J. P. S. Barber, W. Blackwell, H. C. S. Fothergill, J. F. F. McQueen, T. C. Rowland, and Major L. V. W. Clark, *Hon. Secretary*) and of the Ladies Committee (Mrs. Clark, Mrs. MacElewee, Mrs. McQueen, Mrs. Marshall, and Mrs. Brozyna).

International Congresses.

World Petroleum Congress.

The Third World Petroleum Congress was scheduled to be held in Berlin in June 1940. The Council had offered its co-operation in organizing British participation in the Congress and had appointed a Committee (Mr. J. Kewley, *Chairman*, and Messrs. C. A. P. Southwell, W. W. Goulston, J. A. Oriel, F. H. Garner, R. K. Fischer, A. C. Hartley and C. W. Wood) to invite Papers for presentation at the Congress. Owing to the difficulties of the international situation little progress was made, and all arrangements have been in abeyance since the outbreak of war.

Permanent Council of World Petroleum Congresses.

Two meetings of the Permanent Council of World Petroleum Congresses were held during the year :

28*th January*, 1939, at Brussels. Present : Col. L. Pineau, Prof. P. Erculisse, Ir. J. H. C. de Brey, S. Scheer, J. Filhol, S. J. Astbury, and Dr. F. H. Garner.

4*th March*, 1939, in Dusseldorf. Present : Col. L. Pineau, Dr. A. Bentz, Ir. J. H. C. de Brey, T. Dewhurst, Prof. Erculisse, S. Scheer, J. Filhol, S. J. Astbury, and Sr. Roberti.

At the meeting in Brussels Dr. A. Bentz (President of the Deutsche Gesellschaft fur Mineralölforschung) and Sr. U. Puppini (Director of Azienda Generale Italiane Petroli, representative of Italian interests) were co-opted members of the Permanent Council, and Dr. Streintz (former President of the Austrian Petroleum Institute) relinquished his membership of the Permanent Council.

At the meeting in Dusseldorf the organization of the Third Congress proposed by the German Committee was approved. A Preliminary Circular relating to the Third Congress was issued to all members of the Institute in June 1939.

World Automotive Engineering Congress.

A World Automotive Engineering Congress, organized by the Society of Automotive Engineers (U.S.A.), was held in New York, Indianapolis, Detroit, Chicago, and San Francisco between 22nd May and 8th June,

1939. An exchange of greetings was made between the Congress and the Institute.

Dr. A. E. Dunstan (Past-President) addressed the Congress in New York on 22nd May on "Petroleum, To-day and To-morrow."

The Congress was attended by many members of the Institute in U.S.A.

International Geological Congress.

The XVIIIth International Geological Congress scheduled to be held in London in August 1940, was postponsed *sine die* on the outbreak of war.

Chemical Engineering Congress.

Arrangements for the holding of the Second Chemical Engineering Conference in Berlin in 1940 were well advanced during the early part of 1939, but were cancelled in September.

International Standards Association.

The Annual Meeting of I.S.A. was held in Helsinki in June 1939. The Institute was not directly represented at this meeting, but only indirectly through the British Standards Institution.

Publications.

The Journal.

Vol. 25 of the *Journal* was published in twelve monthly parts and contained 35 Papers presented at meetings of the Institute, 5 Papers presented at Branches, and 20 contributed articles. In addition, there were published 1406 Abstracts of technical literature and patents.

The issues of June and July 1939 contained the Papers presented at the Symposium on "Dangerous Gases." These Papers have also been reprinted as a book.

The Papers on "Fuels and Lubricants" presented to the Birmingham Meeting were published in the issues of the *Journal* of September–December, 1939.

Annual Reviews of Petroleum Technology, Vol. IV.

The fourth volume in the series of *Annual Reviews of Petroleum Technology* was published in August 1939. Additional chapters were included on "Refinery Plant and Engineering" and "Pyrolysis and Polymerization," respectively. The outbreak of war unfortunately seriously interfered with the sales of this volume of the *Annual Reviews*, but the Council contemplates the publication of a fifth volume in the series during 1940.

Awards.

Two scholarships of £40 each, tenable by Students of the Institute at the Universities of London and Birmingham for the year 1939–40, were awarded to H. A. de Freitas (Royal School of Mines), and D. G. Brunner (Department of Oil Engineering and Refining, Birmingham University), respectively.

V. G. Norris, Stud.Inst.Pet. (Birmingham University), was awarded

the Students Medal and a Prize for an essay on "Porous Flow and its Application to Increased Recovery from Petroleum Reservoirs."

A Special Prize was also awarded for the highly commended essay of N. V. Munster, Stud.Inst.Pet. (Birmingham University), on "Addition Agents for Lubricating Oils."

Meeting of U.S.A. Members.

The fifth annual meeting of members of the Institute in U.S.A. was held at the Stevens Hotel, Chicago, on 15th November, 1939. Dr. Gustav Egloff presided over an attendance of about 250 members and their guests. Guests of honour included Mr. T. A. Boyd, Mr. E. W. Webb, and Mr. T. Midgley.

Dr. Graham Edgar gave an address on "The Manufacture and Use of Tetra-Ethyl Lead."

Trinidad Geological Conference.

April 18th–27th, 1939.

The Trinidad Branch of the Institute was associated with a Geological Conference convened under the auspices of the Petroleum Association of Trinidad and held in the island on 18th to 27th May, 1939.

The Hon. R. S. MacKilligin, O.B.E., M.C. (Fellow), acted as Chairman of the Organizing Committee; Mr. E. C. Scott (Member) was Vice-Chairman and Secretary.

A short report of the Conference was given in the March 1940 issue of the *Journal*.

Branches and Groups.

Reports of the activities of the Branches of the Institute in the United Kingdom and overseas will be published in the *Journal* as they become available.

Meetings of the Branches in the United Kingdom were discontinued in the latter part of 1939, but have been resumed in 1940.

The Asphaltic Bitumen Group and the Lubrication Group have considerably assisted the programme of meetings during the early part of 1940 by making their London meetings open to the general body of members.

Library.

During the period January–August, 1939, 240 books or periodicals were lent to members, approximately equal to the number lent over the same period during 1938.

Since the outbreak of war the Library has not been available for the loan of books. It was possible to transfer only a limited number of books to Birmingham, so that the bulk of the Library remains at the Adelphi. The bookcases have been covered over with plywood to ensure that the books remain untouched and in good condition.

The Council is indebted to the Institution of Mechanical Engineers and the Imperial College of Science and Technology for their courtesy in

extending library facilities to members during such time as their own library is not available.

The following periodicals have been added to the list of those regularly taken by the library during the year :—

Germany.	*Automobiltechnische Zeitschrift.*
	Motortechnische Zeitschrift.
Japan.	*Journal of Society of Chemical Industry of Japan.*
Turkey.	*Maden Tetkik ve Arama.*
United Kingdom.	*Petroleum.*
U.S.A.	*Chemical Abstracts.*
U.S.S.R.	*Vostochnia Neft.*

The Council records its thanks to the various Government departments, authors, and publishers who have generously presented publications to the library.

Research.

International Research on Viscosity.

A conference of the International Standards Association Sub-Committee 28.a.18 (Viscosity of petroleum products) was held in Brussels on 26th–28th January, 1939. The Institute was represented by Dr. F. H. Garner (Chairman, Viscosity Panel), Dr. G. Barr (N.P.L.), and the Secretary. This conference agreed to initiate a series of international determinations of viscosity, in order that comparison could be made of centistokes as determined in various countries.

The Association Française de Normalisation was primarily responsible for this research, in its capacity as secretariat of I.S.A. Committee 28.a.18. The Viscosity Panel of the Institute of Petroleum, however, played a prominent part in the organization of the work, and the Research Fund of the Institute provided the necessary finance.

Sixteen laboratories agreed to co-operate in the tests, representing seven different countries. It was decided that these laboratories should purchase Ostwald Viscometers, Nos. 2 and 3, standardized at the National Physical Laboratory, England. The Institute placed the orders for the viscometers and agreed to pay the cost of calibration for those national standardizing associations not prepared to meet this expense. The laboratory of the Bataafsche Petroleum Mij., Amsterdam, prepared and circulated a set of samples of three oils to all participating laboratories.

The programme of tests to be carried out on the samples of oil comprised the determination of the times of flow on the Ostwald tubes and the determination of the kinematic viscosity in centistokes on the national standard instrument of the country concerned. In this way it was hoped to be able to check the differences between centistokes as determined in the various countries co-operating in the tests.

The first part of the programme was successfully carried out according to plan. Samples of oil and calibrated Ostwald tubes were despatched before the end of June 1939 to the following laboratories :—

L'Ecole Nationale Superieure du Petrole (France).
Laboratorium voor Chemische Technologie der Technische Hoogeschool, Delft (Holland).
Chemisch Laboratorium der N.V. tot Keuring van Electrotechnische Materialen (Holland).

Laboratorium der Staatsmijnen (Holland).
Centraal Institute voor Materialonderzoek (Holland).
Standard American Petroleum Co. N.V. (Holland).
Laboratorium der N.V. Bataafsche Petroleum Mj. (Holland).
Dansk Standardiseringgraad (Denmark).
Statens Provingsanstalt (Sweden).
Physikalisch-Technische Reichsanstalt (Germany).
Standard Inspection Laboratory (U.S.A.).
Esso European Laboratories (England).
National Physical Laboratory (England).
Anglo-American Oil Company (England).
Burmah Oil Company (England).
Texas Oil Company (England and U.S.A.).

The dates for the viscosity determinations were fixed for the end of September and the beginning of October. Unfortunately, the outbreak of war seriously interrupted the work. A few of the laboratories were able to carry out the tests on the dates agreed, but as the majority of the laboratories were unable to do so, fresh dates were selected in January and February 1940.

Results had been received prior to 1st May, 1940, from six of the co-operating laboratories. When further results have been received they will be correlated at the National Physical Laboratory, with reference to the times of flow.

Steels for Use at High Temperatures.

A grant of £25 was made to the British Electrical and Allied Industries Research Association in aid of investigations on the Creep and Corrosion of Steel at High Temperatures.

Other Research Grants.

Research grants in continuation of previous grants have also been made to Professor F. Challenger (University of Leeds) and Dr. G. M. Dyson (Loughborough Technical College).

Council and Officers.

Professor A. W. Nash, M.Sc., M.I.Mech.E., assumed the Presidency of the Institute in succession to Lt.-Col. S. J. M. Auld at the Annual General Meeting of 27th April, 1939. Professor Nash has been elected by the Council for a second term of office as President for the year 1940–41.

Mr. Ashley Carter, Mr. C. Dalley, Dr. F. H. Garner, Mr. J. McConnell Sanders, and Dr. F. B. Thole have been elected Vice-Presidents for the year 1940–41.

The following were elected members of Council as a result of the ballot declared at the Annual General Meeting of 1939: Mr. G. H. Coxon, Dr. E. B. Evans, Mr. A. C. Hartley, Mr. J. S. Jackson, Mr. H. C. Tett, and Dr. A. Wade.

Acknowledgments.

The Council records its appreciation of the services to the Institute of the Rt. Hon. Lord Plender, G.B.E., Honorary Treasurer; Messrs. Price, Waterhouse & Co., Auditors; Mr. T. Outen of Messrs. Ashurst, Morris,

Crisp & Co., Solicitors, for his help and advice in many problems arising out of the war; and the members of the Staff.

It also wishes to thank the Council of the Institution of Chemical Engineers for permission to hold Council and Committee meetings at its premises in Victoria Street; and the Midland Bank, Ltd., Selly Oak, Birmingham, for banking facilities.

Approved for publication on behalf of the Council of the Institute.

ALFRED W. NASH, President.
ARTHUR W. EASTLAKE, Honorary Secretary.
S. J. ASTBURY, Secretary.

2nd May, 1940.

THE INSTITUTE

REVENUE ACCOUNT FOR THE

	£ s. d.	£ s. d.	1938 £
To **Administration Expenses :—**			
Staff Salaries	1686 1 1		1616
Printing and Stationery	293 16 7		281
General Postages	203 7 1		254
Telephone, Cables, and Telegrams	20 0 5		28
		2203 5 2	
„ **Establishment Charges :—**	£ s. d.		
Rent and Rates	2808 19 4		
Less Grant in aid of Rent	2000 0 0		
	808 19 4		600
Cleaning and Lighting	16 13 7		75
Repairs and Renewals	140 13 7		45
		966 6 6	
„ **Publications :—**			
Journal Expenses	1635 3 7		1508
Abstractors' Fees	221 6 7		253
Postage on Journals	216 12 8		185
Cost of other Publications	485 7 2		907
		2558 10 0	
„ **Meetings :—**			
Hire of Hall, Preprints, Reporting	283 9 1		
Birmingham Meeting Expenses	124 17 9		
		408 6 10	461
„ **Professional Fees :—**			
Legal Expenses	31 10 0		146
Auditors' Fee	42 0 0		42
		73 10 0	
„ **Students Scholarships and Prizes**		88 2 3	80
„ **Library Expenditure**		40 0 10	60
„ **Branches and Sections :—**			
Students Section	17 17 11		39
Trinidad Branch	40 0 0		40
Northern Branch	35 0 0		—
Scottish Branch	5 0 0		—
South Wales Branch	10 0 0		—
Rumanian Branch	3 3 0		—
Branch Lectures	49 4 6		—
		160 5 5	
„ **Sundry Expenses**		184 3 3	164
„ **Depreciation of Office and Library Furniture and Library Books**		50 0 0	12
„ **Removal and other Expenses in connection with requisitioning of The Adelphi**		236 4 3	—
„ **Balance, being surplus for year, carried to Balance Sheet**		154 15 11	—
		£7123 10 5	

RESEARCH FUND INCOME AND EXPENDITURE

	£ s. d.	£ s. d.	£ s. d.
To **Grants Made During Year :—**			
B.E.A.I.R.A.		25 0 0	
Prof. Challenger (Leeds University)		20 0 0	
Loughborough Technical College (Dr. Dyson)		13 17 8	
	£ s. d.	58 17 8	
„ **Research on Viscosity**	79 5 8		
Less Payments received from participating laboratories	62 8 3		
		16 17 5	
			75 15 1
„ **Balance as at 31st December, 1939**			147 14 4
			£223 9 5

OF PETROLEUM

YEAR ENDED 31 DECEMBER, 1939

	£ s. d.	£ s. d.	1938
By Subscriptions for 1939 Received	3893 16 6		
Special Subscriptions	20 0 0		
		3913 16 6	3617
„ Subscriptions in Arrear Received During Year		94 7 1	157
„ Publications		2890 14 7	2922
„ Interest and Dividends, Gross		224 12 3	212
		£7123 10 5	

ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1939.

	£ s. d.
By Balance as at 31st December, 1938	213 7 8
„ Interest Received During Year	10 1 9
	£223 9 5

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

	£ s. d.	£ s. d.	£ s. d.
Capital of the Institute under Bye-Law, Section 6, Paragraphs 14 and 15 :—			
Life Membership Fund—	£ s. d.		
As at 31st December, 1938 . . .	762 15 0		
Additions during year. . . .	48 12 0		
		811 7 0	
Entrance and Transfer Fees—			
As at 31st December, 1938 . .	3172 0 6		
Additions during year— £ s. d.			
Entrance fees . . . 226 9 3			
Transfer fees . . . 139 13 0			
	366 2 3		
		3538 2 9	
Profit on Sale of Investments—			
As at 31st December, 1938		351 10 11	
Donations—			
As at 31st December, 1938		326 5 0	
			5027 5 8
Research Fund			147 14 4
T. C. J. Burgess Prize Fund			10 0 0
Members' Subscriptions Received in Advance .			115 6 6
Journal Subscriptions Received in Advance . .			259 0 6
Sundry Creditors—General Account . . .			1320 14 4
World Petroleum Congress			161 19 8
Revenue Account :—			
Balance as at 31st December, 1938		1791 8 10	
Add Surplus for year as per Separate Statement . .		154 15 11	
			1946 4 9
			£8988 5 9

ALFRED W. NASH, President.
C. DALLEY, Chairman, Finance Committee.
S. J. ASTBURY, Secretary.

AUDITORS'

We report to the Members of THE INSTITUTE OF PETROLEUM that we have obtained all the information and explanations we have required. We are of opinion view of the state of the Institute's affairs at 31st December, 1939, according to the of the Institute.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
1st May, 1940.

OF PETROLEUM.

and not having a Share Capital.)

AT 31ST DECEMBER, 1939.

	£ s. d.	£ s. d.
Investments :—		
On Account of Capital—		
£461 12 0 3% Conversion Stock (1948/53)	491 12 6	
664 6 6 3% London County Consolidated Stock, 1920	481 10 6	
806 8 3 3% Manchester Corporation Redeemable Consolidated Stock, 1958	845 17 7	
867 8 6 2¾% Bristol Corporation Redeemable Stock, 1955/65	845 17 7	
150 0 0 5% Wandsworth and District Gas Company Debenture Stock	154 8 6	
400 0 0 3% Metropolitan Water Board "A" Stock, 1963	346 10 7	
125 0 0 5% Great Western Railway Co. Consolidated Preference Stock	105 4 9	
150 0 0 3% Luton Corporation Redeemable Stock, 1958	151 6 7	
150 0 0 3% Smethwick Corporation Redeemable Stock, 1956/8	151 4 9	
600 0 0 3% Bristol Corporation Redeemable Stock, 1958/63	597 7 3	
		4171 0 7
(Market Value at 31st December, 1939, £3796 19*s.* 1*d.*)		
Cash awaiting Investment on Deposit with Post Office Savings Bank		856 5 1
		5027 5 8
On Account of Revenue—		
£790 8 3 3% Conversion Stock	842 8 0	
On Account of Research Fund—		
£336 5 10 3% Conversion Stock	357 14 8	
		1200 2 8
(Market Value at 31st December, 1939, £1101 7*s.* 1*d.*)		
Office and Library Furniture (Excluding Presentations) :—		
As at 31st December, 1938	180 0 0	
Less Depreciation	30 0 0	
		150 0 0
Library Books (Excluding Presentations) :—		
As at 31st December, 1938	20 0 0	
Less Depreciation	20 0 0	
		—
Subscriptions in Arrears :—		
Not valued.		
Sundry Debtors and Payments in Advance :—		
Sundry Debtors, less Reserve for Doubtful Debts	334 11 7	
Payments in Advance	156 15 3	
		491 6 10
Cash at Bank		249 12 4
Cash on Deposit—		
Post Office Savings Bank	1707 18 7	
World Petroleum Congress Account	161 19 8	
		1869 18 3
		£8988 5 9

REPORT.

examined the above Balance Sheet with the books of the Institute and have that such Balance Sheet is properly drawn up so as to exhibit a true and correct best of our information and the explanations given to us and as shown by the books

PRICE, WATERHOUSE & Co.

BENEVOLENT FUND.

RECEIPTS AND PAYMENTS ACCOUNT FOR YEAR ENDED 31ST DECEMBER, 1939.

RECEIPTS.	£ s. d.	£ s. d.	PAYMENTS.	£ s. d.	£ s. d.
Balance on Current and Deposit Accounts on 1st January, 1939 :—			**Benevolent Fund :—**		
Benevolent Fund Account	718 15 7		Grants in aid		32 0 0
Specific Endowment Fund	43 2 11		**Specific Endowment Fund :—**		
		761 18 6	Grant in aid	34 14 10	
Receipts during 1939 :—			Income Tax	8 8 1	
Subscriptions	39 8 0				43 2 11
Donations	13 2 0		**Balance on 31st December, 1939 :—**		
Interest	15 0 0		Benevolent Fund	763 2 0	
Income Tax recovered	8 16 5		Specific Endowment Fund	nil	
		76 6 5			763 2 0*
		£838 4 11			£838 4 11

* The Balance on Current and Deposit Accounts and invested on 31st December, 1939, was made up as follows :—

	£ s. d.
Cash on Current Account	34 5 0
Deposit Account	200 0 0
3% Local Loans at cost	528 17 0
(Market value at 31st December, 1939: £483)	
	£763 2 0

A. E. DUNSTAN, Chairman, Benevolent Fund Committee.
ALFRED W. NASH, President.

We have examined the above Receipts and Payments Account with the books and vouchers of the Fund and find it to be in accordance therewith. We have verified the Investments and Balances with Bankers comprising the Balance on 31st December, 1939: £763 2 0.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C.2.
1st *May*, 1940.

PRICE, WATERHOUSE & Co.

TRINIDAD BRANCH.

REPORT OF THE COMMITTEE ON THE WORKING OF THE BRANCH DURING THE SESSION 1938–1939.

THE Committee regrets that it was not possible to hold the Annual Meeting as usual in November.

Five Meetings were held during the session, at which the following papers were read :—

1939	
22*nd Feb.*	Sedimentary Conditions of Producing Horizons at Forest Reserve, by Mr. C. S. Lee.
22*nd March.*	Auger and Core Drilling for Geological Purposes in Trinidad, by Mr. E. C. Scott.
26*th April.*	Some notes on Plunger-lift Operation, by Mr. Frank R. Wellings.
31*st May.*	Geologist with a Camera, by Dr. Arthur G. Hutchison.
28*th June. Film.*	"The Inside Story" presented by the marketing division of T. O. F. O. Co.

The average attendance of members and guests at meetings was twenty-five.

There were seventy-nine members on the roll at the end of the year.

Mr. J. L. Harris was elected chairman and Mr. H. C. H. Thomas was elected Honorary Secretary and Treasurer for the session.

The Annual Dinner for the 1938 session was finally held on 14th January, 1939. The Acting Governor attended, and some ninety members and guests were present.

The Committee wishes to record its appreciation of the services to the Branch of Mr. J. L. Harris, who resigned the Chairmanship in August 1939 on leaving the colony. Mr. L. A. Bushe was elected Chairman for the remainder of the session.

The Committee also wishes to record the thanks of the Branch to Mr. F. Middleton and Mr. D. M. Walsh for their services as auditors.

(Sd.) *H. C. H. Thomas*,
Hon. Secretary and Treasurer.

L. A. Bushe,
Chairman.

PRICE, WATERHOUSE & Co.

1st May, 1940.

TRINIDAD BRANCH.

Income and Expenditure Account.

Expenditure			Income	
Dinner Expenses :			Grants from Institute of Petroleum, London	$192·00
Expenditure	$293·29			
Income	276·64			
Loss on dinner		16·65		
Miscellaneous Expenses :				
Stationery, Printing, Stamps		40·41		
Clerical Assistance		17·00		
Excess Income for year		117·94		
		$192·00		$192·00

Balance Sheet as at 31st October, 1939.

Liabilities.			Assets.	
Subscription to Benevolent Fund, to be remitted to London		$72·90	Cash in Bank	$363·51
			Cash in Hand	5·00
Income and Expenditure Account as at 31st October, 1938	$177·67			
Add Excess Income for year ended 31st October, 1939	117·94			
As at 31st October, 1939		295·61		
		$368·51		$368·51

(*Sgd.*) L. A. Bushe,
Acting Chairman.

H. C. H. Thomas,
Hon. Sec. and Treasurer.

F. Middleton
D. M. Walsh
} *Auditors.*

SCOTTISH BRANCH.

REPORT FOR YEAR 1939.

THE Branch made an auspicious start following upon the Empire Exhibition and the first year's activities have been characterised by much energy and enthusiasm.

The Inaugural Meeting held in Edinburgh on the 20th January was attended by a large audience representative of all important scientific societies in Scotland. The President, Lieut.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc., after conveying the greetings and congratulations of the Council, took as his subject "The New Outlook on Lubrication."

At the second meeting on the 16th February held in Glasgow, Mr. G. W. Lepper, A.R.C.S., B.Sc., Technical Adviser to H.M. Petroleum Department, delivered a lecture on "The Search for Oil in Britain." The subject was of topical interest and gave rise to an interesting discussion.

Dr. Wm. Reid of the Fife Coal Co. described, at the third meeting on 24th March in Edinburgh, the problems involved in "The Planning of a Modern Colliery." The lecture was based on the experience gained in the development of the new Comrie Colliery, Fife, and evoked much interest.

The Chairman of the Branch, Mr. Robert Crichton, J.P., presided at all three meetings.

Mr. W. R. Guy, Honorary Recorder, has undertaken the work in connection with general publicity.

Dr. G. H. Smith, Honorary Treasurer, has reported that the Branch finances are in a satisfactory condition.

The Branch is now represented on the Association of Secretaries of Technical Societies in Glasgow, and on the Ramsay Dinner Committee.

The Committee has been engaged in drawing up rules for the conduct of the business of the Branch, but these have not yet been put into effect.

Although an interesting programme had been drawn up for the latter half of the year, including the first Dr. James Young Memorial Lecture by Mr. E. M. Bailey, and addresses by Professor A. W. Nash and Dr. A. E. Dunstan, the Committee unanimously decided, in view of the national emergency, to discontinue operations for the present.

The membership of the Branch, consisting of 55 Members and 51 Branch Members, is drawn from a wide area.

R. CRICHTON, *Chairman.*
W. M. CUMMING, *Hon. Secretary.*

SCOTTISH BRANCH.

FINANCIAL STATEMENT.

1939.

INCOME.	£	s.	d.	EXPENDITURE.	£	s.	d.	£	s.	d.
To Branch Members' Subscriptions, 47 @ 7s. 6d. .	17	12	6	By Expenses of Meetings, Hire of Rooms, Advertising, etc.:						
,, Grant received, 18th Jan., 1939. . . .	5	0	0	20th Jan., 1939	13	4	0			
				24th Mar., 1939	2	3	6			
								15	7	6
				,, Stationery				2	6	3
				,, Postages				1	9	0
								19	2	9
				,, Balance, Cash in hand				3	9	9
	£22	12	6					£22	12	6

3rd May, 1940.

G. H. SMITH, *Hon. Treasurer.*
R. CRICHTON, *Chairman.*

ANNUAL GENERAL MEETING.

16th May, 1940.

THE TWENTY-SEVENTH ANNUAL GENERAL MEETING of the Institute was held at the Royal Society of Arts, John Adam Street, London, W.C. 2, on Thursday, 16th May, 1940, at 5.30 p.m. The Chair was taken by the President, PROFESSOR A. W. NASH.

The SECRETARY read the Notice convening the Meeting and the Reports of the Auditors.

The Minutes of the Twenty-sixth Annual General Meeting were read, confirmed and signed.

NEW MEMBERS.

It was agreed that the list of Fellows, Members, Associate Members, and Students elected and transferred during 1939 should be laid on the table.

ELECTION OF MEMBERS OF COUNCIL.

The SECRETARY announced that, in accordance with the Articles of the Institute, the following members of Council retired at the Annual General Meeting but offered themselves for re-election: Messrs. E. A. EVANS, W. E. GOODAY, C. A. P. SOUTHWELL, A. BEEBY THOMPSON, and C. W. WOOD. One new nomination had been received, on behalf of Mr. J. A. ORIEL, M.A., Manager of Shell Refineries, Ltd. The Council decided that, in view of the present circumstances, a postal ballot should not be held, and the names of the above six candidates were therefore submitted to the Meeting to fill six vacancies on the Council.

On the motion of the PRESIDENT, seconded by Mr. J. KEWLEY, the six gentlemen whose names had been read out by the Secretary were unanimously elected Members of Council.

The PRESIDENT then moved :—

> "That the Annual Report of the Council for the year 1939, together with the Accounts and Balance Sheet as at 31st December, 1939, be and are hereby adopted."

In doing so, he said that the Report had been circulated to all the members, and he would therefore be glad if, for the purpose of the meeting, it might be taken as read. (*Agreed.*)

The Report was a full and comprehensive survey of the activities of the Institute during 1939, and the greater portion of it related to the period prior to the outbreak of war.

He would like first to refer to the two honours mentioned in the Report—namely, those conferred on Sir William Fraser and Sir Thomas Holland. As many of the members were aware, another of the Institute's Past Presidents, Lord Cadman, had recently been elected a Fellow of the Royal Society. He was sure that the members present at the meeting would wish him to express their congratulations to the recipients of these honours. ("*Hear, hear.*")

During the year a re-classification of the membership had been carried out in accordance with the new constitution of the Institute which had been approved two years ago. That re-classification had entailed a long and difficult task for the Election Committee, and the thanks of the Institute were due to Mr. McConnell Sanders and the members of his Committee for the painstaking manner in which they had carried out their task.

A total of 406 Fellows had been elected during the year. A Fellow of the Institute must satisfy the Election Committee and the Council that he had occupied for at

least five years a position of responsibility in the science and technology of petroleum. He could vouch for the fact that that high standard had been rigidly maintained. The Fellowship of the Institute would in future remain a hall-mark of technical standing in the industry.

At the same time the new constitution had been designed to provide for those with responsible positions in the industry, not primarily on the technical side. That had widened the scope of the Institute by making it open to those occupying administrative positions. On the 31st December, 1939, the Institute had 516 Members, 57 of whom had been elected during the year.

Dr. Dunstan would later be speaking to the meeting about the Benevolent Fund, and Mr. Dalley, in seconding the adoption of the Report, would deal more specifically with the accounts, so he would not refer to either of those items in detail.

He felt that the meeting would perhaps expect him to make reference to the transfer of the Institute's office to Birmingham. He had been very pleased to offer to the Council in September 1939 accommodation at the Department of Oil Engineering and Refining at Birmingham University. The Institute had been given less than a week's notice to find alternative accommodation to its offices at the Adelphi. He fully appreciated the disadvantages to the members of not having their own premises available in London. Apart from that, the work of the Institute had gone on as well as war conditions would permit. The *Journal* had been published regularly. Meetings of the Institute and its Groups had been held as far as authors had been available. It had to be remembered that 50 per cent. of the Institute's members were stationed abroad, in the United States, Trinidad, Iran, Iraq, Venezuela, South Africa, Burma, Australia, and other countries, and possibly to the overseas member. Birmingham was as good an address as London for the Institute at the present time.

The Institute's position at the moment was dealt with in the sections of the Report headed "Premises" and "Finance." Along with other members of the Council he was frequently asked when the Institute was coming back to London, and he would be happy to answer that question if he could be told to where it was to return. At the moment the Institute had no premises in London, and until the financial relationships with the Office of Works were straightened out, the Council would be foolish to undertake additional liabilities such as would be entailed by taking new offices in London.

The Institute's Conference on Fuels and Lubricants and its Conference on Dangerous Gases were both referred to in detail in the Report, and there was only one other activity of the Institute during the year to which he would like to direct attention. That was the co-operative research on Viscosity organized by the Institute's Viscosity Panel, under the chairmanship of Dr. Garner, which illustrated a principle operative throughout the whole work of the Standardisation Committee. In the petroleum industry, which spent very large sums every year on research, the contribution which the Institute could make to subsidize research directly would be very small indeed. What a technical society could do, in possibly a unique manner, was to co-ordinate the research proceeding in various countries and laboratories and to bring together the research work done by different companies to a common focus. Although no mention of it was made in the Annual Report, that principle was also being observed in work which was being carried out at the present time on the correlation of methods of testing high-octane fuels for aviation purposes. For obvious reasons details of that work could not be given at the present time, but he might say that it was being carried on with the full co-operation of the Air Ministry and other Government Departments and also of various petroleum companies.

Very little was said in the Report about the activities of the Institute's Branches, but they had made definite progress in the period prior to the outbreak of war. In the early part of 1939 both the Northern Branch and the South Wales Branch had successfully carried out a programme of meetings. The newly formed Scottish Branch had added between forty and fifty members to the Institute's roll. A new Branch had just been formed at Stanlow in Cheshire, in which area there was a very rapidly developing refining centre. The inaugural meeting had been held in the previous week under the chairmanship of Mr. J. S. Parker, and had been addressed by one of the Institute's Past Presidents, Dr. Dunstan. The Council had that day acceded to a request that the Stanlow section should be given the status of a full Branch of the Institute, and he was sure the meeting would like him to convey to that Branch its good wishes for its development and success.

He would like to pay a tribute to the work of Mr. Astbury and his staff, not only for the way in which they had overcome numerous war-time difficulties, but also for the work they had carried out in organizing the Institute's activities earlier in the year 1939, before the war broke out.

In conclusion, he wished to mention that between thirty and forty members of

the Institute were now serving with His Majesty's Forces. He was sure the meeting would like him to send to those members its greetings and best wishes for their safe return. (*Applause.*)

Mr. C. DALLEY, in seconding the motion, directed attention to the market value of the Institute's investments. The market value of the investments on account of capital was given in the Balance Sheet as £3797 at 31st December, 1939, and the market value of the investments on account of revenue and on account of the Research Fund was given as £1101 at the same date. A valuation made more recently showed that they were now back almost at par. Altogether the Council had on deposit at the Post Office Savings Bank the sum of £2663. That would shortly be increased by the deposit of the balance of the World Petroleum Congress Account in the Post Office Savings Bank, so that one-third of the assets of the Institute would be available at short notice.

The difficult position of the Institute with regard to its premises was fully dealt with in the Annual Report, and there was little that he could add, but he would like to say that the Secretary and he had fought their way into the inner sanctuary of the Office of Works and tried every method of persuasion to induce that Department to give the Institute a little reasonable consideration, but all their efforts had been without avail. He could only assure the meeting that the Council and he were making efforts to obtain just compensation from the Office of Works, but their idea of what constituted just compensation seemed to be very different from that of the Office of Works. If any of the members could exercise any influence in the matter, the Council would be very grateful for their help. The oil companies which were making a very generous contribution to the Institute's rental at the Adelphi were standing behind it in its claim.

The Revenue Account called for little comment. The income of the Institute was £214 more in 1939 than it had been in 1938, and the expenditure was £600 less than in 1938. The surplus of £154 15*s.* 11*d.* had been transferred to the Balance Sheet and was available for revenue purposes.

The motion was carried unanimously.

ELECTION OF AUDITORS.

On the motion of Mr. J. T. WARD, seconded by Mr. G. J. C. VINEALL, Messrs. Price, Waterhouse & Co. were unanimously appointed Auditors for the ensuing year.

OTHER BUSINESS.

Captain W. H. CADMAN said that His Majesty's Government had paid a tribute to the importance of the petroleum industry by appointing a Secretary for Petroleum, and he thought it would be appropriate if the members present at the Annual Meeting expressed their appreciation of that appointment by asking the President and Secretary to draft a suitable letter to be sent to Mr. Geoffrey Lloyd, M.P., congratulating him on being appointed the first occupant of that office and wishing him every success in the important duties that he had to perform. He begged to move accordingly.

Dr. E. R. REDGROVE seconded the motion, which was carried unanimously.

The PRESIDENT said that when he and the Secretary had drafted the letter they would send it to each member of the Council for his approval before it was sent to the Secretary for Petroleum.

The proceedings then concluded, and the President declared the meeting closed.

BENEVOLENT FUND.

Annual Meeting of Members.

A meeting of corporate members of the Institute was held at the Royal Society of Arts, London, W.C.2 on Thursday, 16th May, 1940, following the Annual General Meeting, to discuss the position of the Institute's Benevolent Fund.

Dr. A. E. Dunstan (Chairman, Benevolent Fund Committee) occupied the Chair.

In moving the adoption of the Accounts of the Benevolent Fund for the year ended 31st December, 1939, Dr. Dunstan referred to the fact that the total received by way of subscriptions and donations represented only 8*d*. per capita of the total membership of sixteen hundred. He felt sure that members would agree with him that this measure of support was woefully inadequate. The Committee had therefore recently issued an appeal to every member in the United Kingdom to support their own Benevolent Fund more generously. The Institute was still a relatively young society, and the claims upon its Benevolent Fund would necessarily increase as time went on. He appealed particularly to those members in charge of laboratories, departments and offices to initiate whatever means were open to them for regular collections and donations to the Fund.

Mr. Ashley Carter wished to assure the members that every appeal made to the Fund was most thoroughly investigated; not only were full statements obtained, but wherever possible a personal visit was made to the home of the individual making the application. The Fund was operated without any administration expenses, so that members had an absolute assurance that every penny they subscribed to the Fund went to the relief of some unfortunate individual.

Mr. R. J. Bressey strongly urged the Council to adopt the practice of including a space on the annual subscription Form to be filled in with the amount which a member wished to contribute to the Fund. He hoped that members would consider making up their subscriptions of three guineas to £3 10*s*. or £4, the balance being handed over to the Benevolent Fund.

Mr. E. A. Evans, Mr. T. Dewhurst, Mr. J. Kewley, Dr. E. R. Redgrove and Mr. G. J. C. Vineall also made suggestions for increasing the income of the Fund, including a small Benevolent Fund "tax" on the price charged for tickets for various social functions of the Institute, the provision of a collecting box at meetings, etc.

The Chairman thanked the members for all the valuable suggestions which had been made, and which would be considered most carefully by the Benevolent Fund Committee.

The motion for the adoption of the Accounts was seconded by Mr. R. J. Bressey and carried unanimously.